THE IDENTIFICATION AND CLASSIFICATION OF READING DISORDERS BASED ON THE SIMPLE VIEW OF READING

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The material presented in this thesis does not incorporate, without acknowledgement, any material previously submitted for a degree or diploma at any university. To the best of my knowledge and belief it does not contain any material published or written by another person, except where reference is made in the text.

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Abstract

Poor readers are not a homogeneous group of children. Instead, the aetiology and the magnitude of their reading difficulties vary from child to child. Many researchers have attempted to explain this variation through the use of classification approaches. One of the most promising classification approaches is based on the simple view of reading (SVR). This model predicts that impaired reading comprehension ability can result from decoding difficulties, language comprehension difficulties, or a combination of these difficulties, resulting in three poor reader groups. However, when this model has been operationalised, classification studies have identified a fourth group of children whose reading difficulties are not explained by the SVR model.

This study investigated whether alternative classification approaches based on the SVR could provide a better fit for the data. It also sought to address other limitations associated with the traditional classification approach. This study included 209 children in Years 4, 5, and 6 (8–10 years of age, Grades 3–5) from New Zealand primary schools. The children completed 14 individually administered tests that assessed various aspects of their reading comprehension, decoding, language comprehension, phonological awareness, and rapid naming ability. A cluster analysis approach provided the best explanation for children's reading difficulties. This approach identified the three poor reader groups predicted by the SVR model: dyslexia, specific comprehension difficulty (SCD), and mixed reading difficulty. When children were classified using the cluster analysis approach, multinomial logistic regression analyses were able to predict group membership with greater accuracy than they could with any other classification approach investigated in this research. A second set of analyses compared the three poor reader groups across the 14 assessments. These analyses found that the groups demonstrated distinct cognitive profiles. While all the groups demonstrated reading comprehension difficulties, the dyslexia group showed particular weaknesses in word processing and phonological areas, the SCD group showed problems deriving meaning from oral language, and the mixed group showed general deficits in most areas of reading and language processing. A final set of analyses investigated whether the three poor reader groups could be identified using tests that can be accessed by classroom teachers. This approach demonstrated strengths and limitations. The implications associated with the results obtained in this research are discussed, particularly in terms of the usefulness of the SVR model as a way to understand reading difficulties. Future research opportunities are identified, including the need for more school-based work to support teachers in identifying different types of reading difficulties.

Presentations Arising from This Thesis

Sleeman, M., Everatt, J., Arrow, A., & Denston, A. (2020, October 8). *Do groups of poor readers exhibit distinct cognitive profiles?* [Paper presentation]. Literacy Lab, University of Canterbury, Christchurch New Zealand.

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[1]Sleeman, M., Everatt, J., Arrow, A., & Denston, A. (2020). *The identification and classification of students with reading difficulties based on the simple view of reading. Can a three-group model adequately explain students' reading difficulties?* [Poster presentation]. Society for the Scientific Study of Reading.

[1] This conference was cancelled because of COVID-19. The 2020 programme was published online.

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List of Abbreviations

ANOVA	Analysis of variance
BPVS-III	British Picture Vocabulary Scale, version III
Burt	Burt Word Recognition Test
CTOPP-2	Comprehensive Test of Phonological Processing
ERO	Education Review Office
IEA	International Association for the Evaluation of Educational Achievement
NCEA	National Certificate in Educational Assessment
NZCER	New Zealand Council for Educational Research
NZQA	New Zealand Qualifications Authority
OECD	Organisation for Economic Co-operation and Development
PIAAC	Programme for the International Assessment of Adult Competencies
PIRLS	Progress in International Reading Literacy Study
RTLit	Resource Teachers of Literacy
SAC	Special Assessment Conditions
SCD	Specific comprehension difficulty
SEM	Structural equation modelling
SLI	Specific language impairment
SVR	Simple view of reading
TKI	Te Kete Ipurangi
WJIV	Woodcock-Johnson IV

Chapter 1 Introduction

Reading is a complex activity (Hoover & Gough, 1990). In fact, some argue that it is one of the most complex skills that children need to master (Braze et al., 2007). Although most children learn to read, many have difficulty developing this skill. Some estimates suggest that up to 25% of primary aged children exhibit reading difficulties (Joshi & Aaron, 2000; Ministry of Education, 2017). Because numerous classroom activities rely on reading ability, the difficulties these children exhibit are often not limited to formal reading instruction. These children are more likely than their typically achieving peers to demonstrate difficulties across the curriculum (Organisation for Economic Co-operation and Development [OECD], 2016a). This may be one of the reasons why struggling readers are more likely to skip school (OECD, 2016a) and exhibit behaviour difficulties (Horbach et al., 2019) than other children their age. A large proportion of youth prisoners exhibit pronounced reading difficulties (Rucklidge et al., 2013), which suggests that individuals with extreme reading difficulties are more likely to be incarcerated than their typically achieving peers. The negative consequences associated with reading difficulties are not limited to childhood. Adults with limited literacy typically earn less than their more literate peers and are less likely to gain full-time employment (OECD, 2011). The consequences associated with reading difficulties can be profound and enduring.

Children who exhibit reading difficulties should not necessarily be seen as qualitatively different from typically achieving readers – they are likely to use, and show evidence of using, the same reading processes as any learner. Instead, this thesis considers such children as representing the lower end of a distribution of reading ability that ranges from the most able readers to those who experience substantial difficulties developing the skills required to comprehend written text (Catts et al., 2012). While all poor readers fall at the lower end of this continuum, they are not a homogeneous group of children. Researchers have attempted to capture this variation through the use of classification approaches. The literature review section of this thesis describes these approaches. To be considered a valid approach, a classification system must be able to accurately explain the variation in reading difficulties, and there must be some benefit from classifying children in this way (Catts et al., 2003). None of the reviewed classification approaches meet both of these criteria. The most promising classification approach is based on the simple view of reading (SVR), which is the focus of this research.

The SVR is a cognitive model of children's reading comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990). The model predicts that an individual's ability to comprehend written text relies on just two cognitive processes: decoding and language comprehension. Language comprehension involves extracting and constructing literal and inferred meanings from linguistic discourse (Hoover & Tunmer, 2018). Reading comprehension relies on the same cognitive skills. The key difference between reading comprehension and language comprehension is the medium that these skills are applied to. Reading comprehension focuses on text, whereas language comprehension focuses on speech. To apply our language comprehension skills to text we must be able to decode the words on the page. Within this model, decoding is defined as the ability to quickly, accurately, and effortlessly access word meanings from our mental lexicon (Hoover & Tunmer, 2018). Proficient decoding and language comprehension ability are required to comprehend written text.

The SVR predicts that reading comprehension difficulties are due to decoding difficulties, language comprehension difficulties, or difficulties with both of these skills, resulting in three poor reader groups (Gough & Tunmer, 1986). Within this model, the label dyslexia is applied to children who exhibit decoding difficulties in the absence of language comprehension difficulties and the label specific comprehension difficulty (SCD) is applied to children who exhibit the reverse profile. These children exhibit language comprehension difficulties in the absence of decoding difficulties. The mixed difficulty group demonstrate both decoding and language comprehension difficulties. Previous classification studies have identified these groups as well as a fourth group of poor readers, who do not exhibit decoding or language comprehension difficulties (Aaron et al., 1999; Catts et al., 2003; Ebert & Scott, 2016; Morris et al., 2017). The identification of a group of children who exhibit reading comprehension difficulties that are not explained by the SVR could be due to measurement error and/or limitations associated with the methodology that was used in previous SVR studies. It could indicate that some of the children who took part in these previous studies did not actually have reading difficulties. Alternatively, it could indicate that children in the unexplained poor reader group experience reading comprehension difficulties because they exhibit difficulties on a third variable that is not included within the SVR. The authors of the SVR (Gough & Tunmer, 1986) acknowledge that the existence of a group of poor readers who can adequately decode and comprehend language would falsify the SVR hypothesis. The existence of this group might indicate that a third variable needs to be added to the SVR model to provide a more complete account of children's reading difficulties.

This research aimed to address three gaps in the literature. First, it investigated a number of different classification methodologies based on the SVR to determine whether an alternative approach provided a better explanation for children's reading difficulties than the traditional classification approach. The analyses performed in this research did not find additional support for the four-group model identified in previous research. Instead, they found that children could be accurately assigned to one of the three poor reader groups predicted by the SVR. Previous research has not examined in detail the cognitive profiles exhibited by the poor reader groups predicted by the model. This research aimed to address this second gap in the literature by conducting strengths and weaknesses profile analyses for each group across a range of cognitive processes associated with reading. The third research gap relates to the type of tests that have been used in previous classification studies. The SVR has instructional implications for teachers because it identifies the two skills that are proximally related to reading comprehension. However, previous SVR classification studies have assessed children using tests that most teachers are unable to access because of restrictions around their use. This research investigated whether tests with fewer restrictions could be used to classify poor readers. The final section of the literature review describes these gaps in greater detail and lays out the three research questions that guide this research.

Classification studies based on the SVR aim to group children according to their performance on tests that assess children’s decoding and language comprehension ability. The relative importance of decoding and language comprehension to reading comprehension changes over time. In younger children decoding plays a more important role in reading comprehension. However, in older children language comprehension becomes a better predictor of reading comprehension ability (Catts, Hogan, et al., 2005; Georgiou et al., 2009; Hoover & Gough, 1990). This change influences the proportion of poor readers who are assigned to each poor reader group (Catts, Hogan, et al., 2005). The current study focused on children with reading difficulties in Years 4, 5, and 6 (aged 8–10 years, Grades 3–5). At this age, both decoding and language comprehension play an important role in reading comprehension (Catts, Hogan, et al., 2005). In total, 216 children from nine primary schools in an urban centre within the South Island of Aotearoa New Zealand participated in this research. To the knowledge of this author, this is the first time a classification study based on the SVR has been conducted outside of the United States. Research outside of the United States is important because a country’s instructional approach may influence the proportion of children who exhibit reading difficulties and the type of reading difficulties they exhibit.

This thesis is broken into seven chapters. Chapter 2 provides background to this research. The first sections in this chapter describe reading instruction in Aotearoa New Zealand and consider what impact this approach may have on the identification and classification of children with reading difficulties. It then reviews four approaches that have been used to classify poor readers before focusing more closely on classification based on the SVR. Subsequent sections describe the SVR and the cognitive processes that underpin decoding and language comprehension. This chapter then summarises and evaluates previous SVR research. The research gaps identified in this review form the basis for the research questions used in this study. These questions are set out at the end of Chapter 2.

Chapter 3 describes the methodology used in this research. It starts by describing the participants, the participant selection criteria, and the procedures that were followed in this research. It then describes 14 tests that were used to assess children’s ability on five different constructs. These constructs include reading comprehension, decoding, language comprehension, rapid naming, and phonological awareness. Test item descriptions are provided and test reliability figures are reported.

Chapter 4 outlines the analyses that were conducted. These analyses are organised according to the research question they address. Chapter 5 details the results from this research. The first section in this chapter (Section 5.1) reports the descriptive statistics for each of the 14 tests that were administered in this research. Section 5.2 focuses on the classification approaches that were used in this research. Initially, the children who participated in this research were classified using the traditional classification approach based on the SVR. Section 5.2.1 reports the results from this analysis. It also contrasts this approach with three other classification methodologies based on the SVR. The results from these subsequent analyses are reported in Sections 5.2.2 and 5.2.3. Section 5.2.4 provides a summary of these approaches and identifies which of these approaches provides the best explanation for children's reading difficulties. Section 5.3 compares the poor reader groups across a range of cognitive processes using the classification approach that provided the best fit for the data in the previous section. Strengths and weaknesses profile analyses are reported for each group. The results from the classification analyses that were reported in Sections 5.2.1–5.2.3 were all based on tests that most teachers are unable to administer because of restrictions around their use. Section 5.4 reports the results from a classification approach based on tests that are not subject to these restrictions. The results from this analysis are compared with the optimal classification approach that was identified in Section 5.2.4.

Chapter 6 discusses the findings from this research. This chapter starts by summarising the key results reported in the previous chapter in relation to the three research questions that were posed at the start of this thesis. Chapter 6 considers why a three-group model provides a better fit for the data than the approach used in previous studies, which identified four poor reader groups. It then discusses prevalence rates within the poor reader population and estimates the proportion of all children of this age who are likely to exhibit each of the poor reader profiles. The defining characteristics of each poor reader group are then described. With reference to literature, this chapter considers why each group might exhibit their respective profiles. It then discusses the strengths and limitations associated with the classification approach that was based on tests that teachers may be able to access and administer. The final sections of Chapter 6 consider the implications associated with the key findings that have been described in this chapter. It acknowledges limitations associated with this research and identifies future research opportunities based on the findings from this study. Chapter 7 reviews the key findings from this research in relation to the research questions that were posed at the end of the literature review.

Chapter 2 Literature Review

This chapter is broken into 11 sections. Section 2.1 describes the Aotearoa New Zealand context. It compares the reading achievement of children in Aotearoa New Zealand with that of children in other countries and identifies a group of children in Aotearoa New Zealand who exhibit substantial reading difficulties. These children fall at the bottom end of the reading comprehension continuum and are the focus of this research. Section 2.2 identifies factors that may contribute to the difficulties that these children exhibit. These factors include Aotearoa New Zealand’s instruction approach and the resources that have been used to support this approach. Section 2.3 describes some recent changes to Aotearoa New Zealand’s reading instruction that have been mandated by the Ministry of Education. Because most of these changes will take place in 2021 and 2022, children in this research have not benefited from these changes. However, some of these changes are consistent with recommendations made at the end of this thesis.

Poor readers within Aotearoa New Zealand are not a homogeneous group of children. Section 2.4 critiques five classification approaches that have attempted to explain this variation. The most promising of these approaches is based on the SVR. Section 2.5 reviews evidence for the SVR, and Section 2.6 describes the two cognitive processes that contribute to this model: decoding and language comprehension. It also identifies the lower-level cognitive processes that contribute to these skills and considers how these lower-level processes might support decoding and language comprehension.

The relationship between decoding, language comprehension, and reading comprehension was first established through multiple regression analyses (Hoover & Gough, 1990). Section 2.7 reports the results from a meta-analysis, which evaluated the results from studies that adopted this approach. The validity of the SVR has also been investigated through classification studies. Section 2.8 reviews and evaluates these studies and Section 2.9 compares two of the poor reader profiles that have been identified in SVR classification research and other research investigating reading and language comprehension difficulties. Three gaps in the SVR literature were identified as a result of this review. Section 2.10 describes these gaps, and Section 2.11 elaborates on how the current research addresses these gaps.

2.1 The Aotearoa New Zealand Context

Most children in Aotearoa New Zealand learn to become proficient readers. Since 2001, Aotearoa New Zealand has been participating in the Progress in International Reading Literacy Study (PIRLS), which is overseen by the International Association for the Evaluation of Educational Achievement (IEA). Over 5,500 Year 5 children from nearly 200 schools throughout Aotearoa New Zealand took part in 2016, along with children from 49 other countries. Aotearoa New Zealand’s average reading score was significantly higher than the PIRLS scale centrepoint, and 41% of all Aotearoa New Zealand’s participating children reached the high benchmark, which means they were able to engage with increasingly complex texts and questions (Ministry of Education, 2017). Results from the OECD Programme for the International Assessment of Adult Competencies (PIAAC) suggest that most children in Aotearoa New Zealand go on to become proficient adult readers (OECD, 2016b). This research indicates that Aotearoa New Zealand’s average adult score for literacy was significantly higher than the OECD average and 56% of participating adults from Aotearoa New Zealand performed within the top three levels of literacy proficiency. Adults within these top three levels should be able to comprehend increasingly dense and lengthy texts; evaluate multiple pieces of information; make appropriate inferences based on text structure and rhetorical devices; and integrate, interpret, and synthesise complex texts. However, the results from PIRLS (Ministry of Education, 2017) and PIAAC (OECD, 2016b) do not provide a complete picture of reading achievement in New Zealand. The remainder of Section 2.1 focuses on a group of children who demonstrate substantial reading comprehension difficulties. These children are not typically identified in analyses that focus only on average reading scores.

A focus on PIRLS average scores may conceal the difficulties exhibited by a larger proportion of Aotearoa New Zealand's children. Not all countries that participate in PIRLS are similar to Aotearoa New Zealand. For example, PIRLS includes non-English-speaking countries, countries with vast differences in material wealth, and underdeveloped countries. Tunmer et al. (2013b) have argued that a more meaningful comparison can be made by comparing Aotearoa New Zealand with six similar countries: Northern Ireland, the United States, Ireland, England, Canada, and Australia. The 2016 PIRLS data showed that Aotearoa New Zealand's mean reading scale score was worse than all of these countries and a greater proportion of Aotearoa New Zealand's children fell within the bottom two achievement bands (Ministry of Education, 2017). This indicates more widespread reading difficulties within Aotearoa New Zealand than in comparable countries.

Aotearoa New Zealand has a long tail of underachievement in reading that is not captured by average scores. A more complete picture of children's reading comprehension proficiency can be found by also investigating variation in reading performance. Of the 41 richest countries, Aotearoa New Zealand has the second greatest gap between the top 10th percentile and the bottom 10th percentile on the PIRLS assessment (UNICEF Office of Research, 2018). Children at the tail end of this distribution are more likely to come from Māori[2] and/or low-income backgrounds (Tunmer et al., 2013b). This disparity in achievement does not resolve over time. In 2018 nearly 10% of all school leavers did not obtain National

[2] The term Māori refers to the indigenous people of New Zealand.

Certificate in Educational Assessment (NCEA) Level 1 literacy and numeracy credits (Ministry of Education, 2019a). NCEA is the main qualification for secondary school students in New Zealand. *The New Zealand Qualifications Framework* states that NCEA Level 2 provides the foundational skills required for employment (New Zealand Qualifications Authority, n.d.-b). This indicates that many school leavers are not sufficiently literate for the world in which they seek to gain employment. Results from the International Adult Literacy Survey suggest that literacy rates do not improve once children have left the education system. Nearly 12% of adults from Aotearoa New Zealand who participated in this survey demonstrated substantial literacy difficulties (OECD, 2016b). These adults could only read brief texts on familiar topics to answer a literal question requiring the identification of one piece of information from the text. These findings are worrying because adults with limited literacy typically earn less than their more able peers, are less likely to gain full-time employment, and are less likely to engage with community groups and organisations (OECD, 2011).

Concerns about children's reading ability in Aotearoa New Zealand are not new. One of the first studies to reveal the disparity between good and poor readers was conducted by the IEA (Elley, 1992). They found that Aotearoa New Zealand had a greater range of scores than any other participating country. Children at the low end of this continuum were more likely to be Māori or from low socio-economic families. PIRLS data show that there has been little improvement in Aotearoa New Zealand's performance over time. There was no significant improvement in Aotearoa New Zealand's reading performance from 2001, the first year of PIRLS data, to 2011, and the most recent results from PIRLS show that Aotearoa New Zealand's mean score decreased from 2011 to 2016 (Ministry of Education, 2017). The mean reading score for New Zealand European children was significantly higher than the mean reading score for Māori and Pasifika[3] children, a pattern that has not changed since 2001. There are also significant gender differences within the Aotearoa New Zealand sample. The mean reading score for girls is significantly higher than it is for boys, and the difference between boys' and girls' achievement is larger than that of many other countries. Again, this pattern has not changed since the first PIRLS assessments in 2001 (Ministry of Education, 2017).

2.2 Factors Contributing to Aotearoa New Zealand's Underachievement in Reading

Aotearoa New Zealand's instructional approach and the resources used to support this approach may explain why a greater proportion of children in Aotearoa New Zealand demonstrate reading difficulties than do those in comparable countries. Historically, reading instruction in Aotearoa New Zealand has been primarily based on a constructivist, multiple cues approach (Tunmer et al., 2013b). This approach emphasises the use of text meaning, sentence structure, and visual information to decode words (Arrow & Tunmer, 2012; Castles et al., 2018; Tunmer & Chapman, 2007). The multiple cues approach is based on the assumption that learning to read is similar to learning to speak. Proponents of this approach believe that because learning to speak develops naturally, reading ability will also develop without explicit instruction (Arrow & Tunmer, 2012). The multiple cues approach has been rejected by the scientific community (Chapman et al., 2018). This research has shown that contextual guessing does not result in improved decoding ability. In fact, using contextual aids, such as picture cues, is an approach that is most frequently adopted by poor readers rather than more proficient decoders (Arrow & Tunmer, 2012; Castles et al., 2018; Chapman

[3] The term Pasifika refers to the people, cultures, and language of Pacific groups, including Sāmoa, Tonga, the Cook Islands, Niue, Tokelau, Tuvalu, and other smaller Pacific nations, who are now living in New Zealand (Ministry of Education, n.d.).

et al., 2018). Beginning readers who focus on word-based strategies outperform children who rely on other approaches to decode words (Tunmer et al., 2013b).

Text-based instructional approaches draw children's attention to the alphabetic code through explicit instruction (Chapman et al., 2018). Children are taught to use their knowledge of letter–sound relationships and orthographic rules to decode new and unfamiliar words. A substantial body of literature supports this form of instructional approach (Arrow, 2018; Chapman et al., 2018; National Institute of Child Health and Human Development, 2000). In spite of this literature, Aotearoa New Zealand has chosen to focus primarily on a whole language, multiple cues approach, rather than explicit word-level decoding strategies, for over 30 years (Chapman et al., 2018).

There have been attempts to alter Aotearoa New Zealand's instructional approach. In 2001, the Education and Science Committee of the New Zealand Parliament sought to investigate the extent of Aotearoa New Zealand's reading difficulties, including how the gap between poor and typically achieving readers could be closed. The subsequent report made 51 recommendations. These included requiring that all primary teacher education programmes include instruction on phonetic skills and word decoding, advice on how schools can incorporate phonics instruction within their programmes, and a greater emphasis on phonics in literacy instruction material. However, these recommendations were not accepted by the government (Tunmer et al., 2013a).

Resources provided to schools by the Ministry of Education have reflected Aotearoa New Zealand's whole language approach. This emphasis is peppered throughout instructional literature provided to teachers. *The New Zealand Curriculum* (Ministry of Education, 2007b) sets the direction for learning in schools across eight curriculum areas. This document identifies indicators of success for children in Years 1–13. The first level of indicators is designed for children in the early school years. One of these indicators states that children should be able to “use sources of information (meaning, structure, visual and grapho-phonic information) and prior knowledge to make sense of a range of texts” (Ministry of Education, 2007b, p. 47). The curriculum states that in Year 2 children should be able to “select and use sources of information (meaning, structure, visual and grapho-phonic information) and prior knowledge with growing confidence to make sense of increasingly varied and complex texts” (Ministry of Education, 2007b, p. 50). These statements direct educators to teach children to decode words using the multiple cues approach.

A more recent document, called *The Literacy Learning Progressions,* was developed to describe “the specific literacy knowledge, skills, and attitudes that students draw on in order to meet the reading and writing demands of the curriculum” (Ministry of Education, 2010, p. 4). These progressions have been criticised for failing to focus on the progression of skills that are required to decode words (Arrow, 2018). Instead, they have emphasised the need for a multiple cues approach to word decoding. This document frequently references the Ready to Read series, which is the core instructional reading series used within junior classrooms in Aotearoa New Zealand. Children are expected to progress through the magenta, red, yellow, and blue Ready to Read levels within their first year of schooling. *The Literacy Learning Progressions* state that at the yellow level children should be “developing their ability to search for and use interrelated sources of information (semantic, syntactic, and visual grapho-phonic)” (Ministry of Education, 2010, p. 12) and by level blue children should “apply their reading processing strategies to longer or more varied texts. They need to monitor their reading, searching for and using multiple sources of information in order to confirm or self-correct” (Ministry of Education, 2010, p. 12). Progress through the Ready to Read series has been monitored through the use of running records. In addition to being an unreliable measure of reading achievement (Tunmer et al., 2013b), running records encourage teachers to analyse errors using a multiple cues approach. These resources communicate the Ministry of Education's intention for children in Aotearoa New Zealand to be taught to read using a whole language approach.

The Ready to Read series is designed to support the teaching of a whole language approach. Even at early levels, these books include complex words with digraphs, complex vowel digraphs, and varied morphological patterns (Arrow, 2018). They cannot be used to support a structured, sequential, text-based approach to reading instruction. They provide children with insufficient opportunities to practise specific phonic patterns within each text. Some schools have chosen to supplement these texts with phonics and phonological awareness programmes. However, there have been concerns about the way these programmes have been used in some classrooms (Education Review Office, 2009). The Education Review Office (ERO) found that some teachers were very reliant on commercially produced phonics programmes and failed to match phonics instruction to the needs of children in their classrooms. They found that a relatively small proportion of schools had engaged in professional development in this area (12%) and the professional development that some schools had engaged in was limited to discussions at just one staff meeting over the ERO review period (2007 and 2008).

The instructional material that the Ministry of Education has provided for teachers and the Ready to Read series, which is provided to schools, have resulted in classroom teaching that is primarily based on a whole language approach to reading instruction (Tunmer et al., 2002, 2013b). Many teachers have become reliant on the Ready to Read series for reading instruction (Chapman et al., 2018), and some teachers reject the need for change from the instructional approach that has long been mandated by the Ministry of Education (Chapman et al., 2018). Some other teachers fear they lack the time or ability to learn evidence-based reading instructional practices, and others, who have attempted to change their practice, have found their efforts frustrated by the lack of decodable texts available in schools (Chapman et al., 2018).

Through the assessment page on their website, the Ministry of Education has attempted to support teachers by identifying a small range of tools that can be used to assess literacy-related skills (Ministry of Education, n.d.-a). A small number of standardised assessments are included within this list. These assessments include the e-asTTle Reading test (Auckland UniServices Limited, 2009) and the Progressive Achievement Test for Reading Comprehension (Darr et al., 2008). These tests can be used to track progress over a year but are less sensitive to the daily, weekly, or monthly progress that occurs within classrooms (Johnson & Street, 2013). Teachers are also encouraged to use running records, or similar resources, and evaluate children's progress against *The Literacy Learning Progressions* (Ministry of Education, 2010). Limitations associated with running records and *The Literacy Learning Progressions* have been described in previous paragraphs. The Ministry of Education website (Ministry of Education, n.d.-a) does not describe a cohesive assessment approach that could be used to identify at-risk learners, monitor children's progress, identify the root cause of reading difficulties, or inform instructional practice. The Literacy Online page on the Ministry of Education's website provides greater guidance (Ministry of Education, 2021b). It identifies three baseline assessments that can be used with beginning readers and describes how the results from these assessments can be used to determine the instructional starting point for these children. These tests assess children's knowledge of letter names and sounds (Alphabet Test), their ability to identify, blend, and manipulate the sounds of speech (GKR Phonemic Awareness Test), and their ability to apply word attack strategies (Adapted Bryant Test of Basic Decoding Skills).

It is likely that reading instruction over the past 30 years in Aotearoa New Zealand has been insufficient for many children. This has resulted in a long tail of underachievement in reading (UNICEF Office of Research, 2018). The Ministry of Education funds a remedial reading programme, called Reading Recovery, which is available to some children who fall at this lower end of the reading continuum. Unfortunately, this programme is based on a whole language instructional approach. The programme provides one-to-one instruction from a teacher trained in Reading Recovery in addition to a child's regular classroom instruction. Reading Recovery was designed for children who are making the slowest reading progress after one year at school. However, not all schools offer Reading Recovery. The most recent data indicate that only 55% of state schools offer this programme and this figure has steadily declined since 2005 (Ministry of Education, 2018). This means that some children with pronounced reading difficulties cannot access additional reading support because their school has chosen not to provide Reading Recovery support. In schools that provide Reading Recovery, the programme is offered to children exhibiting the greatest reading difficulties. This has resulted in some children being accepted into the Reading Recovery programme with a level of reading proficiency equivalent to the level at which other children exit the programme. This occurs because some children attend schools where a large proportion of the children exhibit substantial reading difficulties, and in other schools a smaller proportion of children exhibit less pronounced difficulties. Despite this difference in need, a similar proportion of children are offered Reading Recovery assistance. These funding and resourcing decisions have led to inequitable access to reading support. There is evidence that Reading Recovery is less effective for children who exhibit the greatest reading difficulties (Tunmer et al., 2013b). Māori (67%) and Pasifika (71%) children are less likely to be successfully discontinued from the programme than New Zealand European children (78%). Boys are also less likely to be successfully discontinued from the programme (Ministry of Education, 2018). It is worrying that Aotearoa New Zealand's remedial reading programme appears to be the least effective for children who are most likely to fall within the tail end of the reading achievement distribution.

In secondary schools, the focus often shifts from remedial programmes to accommodations. Schools can make applications for Special Assessment Conditions (SAC) to the New Zealand Qualifications Authority (NZQA) on behalf of children who have specific learning difficulties. These accommodations can include the use of a reader or a writer, or the provision of extra time for New Zealand's NCEA assessments, the main qualification for secondary school students in Aotearoa New Zealand. A school's application can be based on either school-collected evidence or an educational assessment written by a registered professional (NZQA, n.d.-a). Educational assessments have been more commonly used to support SAC applications for children in higher rather than lower socio-economic communities (NZQA, 2020). This may be due to the cost of educational assessments, which are typically borne by parents. Financial constraints may mean that some families are unable to access educational assessments, resulting in inequitable access to SAC.

Some children who fall within the lower end of the reading comprehension continuum exhibit difficulties consistent with a specific learning difficulty in reading. Traditionally, Aotearoa New Zealand has opposed the use of labels such as specific learning difficulty and dyslexia (Tunmer & Chapman, 2007). It was feared that the use of labels may stigmatise some ethnicities who are more likely to exhibit reading difficulties. Instead, it has focused on the inclusion of all children within a world class inclusive education system (Ministry of Education, 1996). Inclusion is one of eight principles that underpin *The New Zealand Curriculum* (Ministry of Education, 2007b). The curriculum emphasises the importance of celebrating diversity, providing equitable learning opportunities, and recognising and meeting the needs of all learners. The use of labels has been criticised as a deficit-based approach that is not consistent with inclusion (Hornby, 2012; Runswick-Cole & Hodge, 2009), which is one reason why labels such as dyslexia have not been encouraged within the Aotearoa New Zealand education system. Dyslexia was officially recognised within Aotearoa New Zealand in 2007 (Ministry of Education, 2007a). The first official definition included a number of difficulties that are not generally accepted as being characteristic of dyslexia. These included difficulties reading music and numbers. It also stated that phonological awareness was a reading skill, rather than correctly identifying it as a language skill (Ministry of Education, 2016). The Ministry of Education provided some basic checklists to help teachers identify dyslexia but no actual assessments were provided. In 2012, Nicholson and Dymock (2015) surveyed teachers on their ability to identify and support children with dyslexia. Their results indicated that the checklists provided by the Ministry of Education offer insufficient support. Most of the respondents (95%) believed they had children with dyslexia at their school but few believed they could identify these children (65%) and even fewer believed they were equipped to support children with dyslexia (12%). This suggests that many teachers are ill-prepared to address the instructional needs of children with dyslexia in their classrooms.

2.3 Recent Changes

A number of recent changes in policy may lead to improved reading outcomes for children in Aotearoa New Zealand. Some of these changes took place in 2020, and others are planned to take place in 2021 and 2022. This means the impact of these changes is not yet visible in reading achievement data.

In 2021, the Ministry of Education will provide decodable books to all schools in Aotearoa New Zealand (Ministry of Education, 2021a). The Ministry of Education's Te Kete Ipurangi (TKI) website now states that these should be used to support the explicit teaching of phonics and directs teachers to a 2018 study by Chapman and colleagues (2018) that describes how a systematic, structured, and explicit literacy programme can be used to enhance the literacy outcomes for beginning readers. The Ministry of Education is also providing additional training for some teachers through the Better Start Literacy Approach at the University of Canterbury (University of Canterbury, 2021). The Better Start Literacy Approach is a classroom programme that is based on several research trials that investigated the most efficient and effective methods to support children with their reading, writing, and oral language (Gillon et al., 2019, 2020). This approach provides evidence-based reading instruction within a culturally responsive framework referred to as a braided rivers approach. The braided rivers approach emphasises the importance of cultural identity, resilience, a sense of place, bicultural education, and extended family or whānau (Gillon & Macfarlane, 2017). The trials focused on children from low socio-economic communities and found that children who were exposed to this programme made significantly greater gains in reading-related skills than children who received their typical classroom instruction. The programme was effective for both boys and girls, and children who identified as Māori or Pasifika made similar progress to children who identified as New Zealand European (Gillon et al., 2019). These findings are particularly important because Aotearoa New Zealand's traditional reading instruction approach has often failed these groups of children.

Recent changes have also been made to the role Reading Recovery teachers play within schools. Reading Recovery teachers will now incorporate decodable texts within their lessons along with other resources that are based on a scope and sequence (Ministry of Education, n.d.-b). The use of decodable books that follow a scope and sequence are two of the key ingredients in an evidence-based approach to the teaching of reading. Scope refers to the skills that must be included within the programme, and sequence refers to the order in which these skills should be taught (Arrow, 2018). This is a significant change. Traditionally, the Marie Clay Literacy Trust, which holds the copyrights for Reading Recovery, has resisted any change to the Reading Recovery programme and material (Tunmer et al., 2013b). In addition to working one-to-one with struggling readers, Reading Recovery teachers will now be allowed to work with small groups of children who are not making sufficient progress. They will also be able to support teachers to provide effective literacy programmes for all the children in their classes (Ministry of Education, n.d.-b). Currently, only a small number of Resource Teachers of Literacy (RTLit) have been trained to provide specialised literacy assistance to children in Years 1 to 8. These teachers work across a number of schools, which means that demand for their support is often greater than the level of support they can provide. Reading Recovery teachers may be able to reduce the demand placed on the RTLit service.

In 2017, the government responded to the 46 recommendations made by the Education and Science Select Committee report, which inquired into the identification of and support for children with dyslexia, dyspraxia, and autism spectrum disorders in primary and secondary schools (New Zealand Parliament, 2017). A number of key recommendations were accepted. These recommendations included providing schools with additional resources to support teaching children with dyslexia; providing guidelines on how to support children with dyslexia, ensuring policies, approaches, and supports for dyslexia are based on research evidence and best practice; ensuring this evidence is made available to schools and families; identifying options for the earlier identification of dyslexia and other literacy and language needs; providing additional and timely support for children with learning difficulties; providing more equitable access to SAC; strengthening initial teacher and ongoing education for dyslexia; supporting teachers to identify and respond to the needs of children with dyslexia; and lifting the capability of specialist teachers who work with children with dyslexia. Some of these recommendations have now been implemented. The Ministry of Education's TKI website has been updated with information on dyslexia and the revised dyslexia definition (Ministry of Education, 2020) is now consistent with other international definitions (American Psychiatric Association, 2013; International Dyslexia Association, 2002; Rose, 2009). The website provides some clearer guidelines on how teachers can support children with dyslexia, and a copy of *The New Zealand Dyslexia Handbook* (Nicholson & Dymock, 2015) has been provided to every school in Aotearoa New Zealand. This book includes information on how literacy difficulties can be assessed and how teachers can support children with dyslexia. Changes are also being made to Aotearoa New Zealand's initial teacher education programmes. From the first of January 2022, teacher education programmes must include a focus on children with dyslexia (Teaching Council, 2019).

The Ministry of Education's TKI website now includes information on the SVR. It notes that the ability to decode words and comprehend spoken language is essential for skilled reading comprehension (Ministry of Education, n.d.-c). However, it does not explain how the SVR can be used to differentiate between poor readers based on their decoding and language comprehension proficiency. On other pages, the Ministry of Education briefly compares dyslexia and developmental language disorder (Ministry of Education, n.d.-d). It does not make the connection between developmental language disorder and the SCD group predicted by the SVR model; nor does it mention the mixed difficulty group. A relatively large proportion of poor readers are known to exhibit the SCD and mixed difficulty profile (Aaron et al., 1999; Catts et al., 2003; Ebert & Scott, 2016; Morris et al., 2017) so a greater focus on how teachers can identify and support children who exhibit these profiles could be beneficial for teachers who work with these children.

If all of these changes have their intended effect, fewer children should develop reading difficulties. Programmes such as the Better Start Literacy Approach may lead to improved outcomes for boys as well as Māori and Pasifika children, which might reduce the proportion of these children who fall within the tail end of Aotearoa New Zealand's reading distribution. Many of the initiatives described here focus on decoding. Difficulty decoding words is the primary difficulty exhibited by children with dyslexia. Children with a mixed difficulty also demonstrate difficulties with this skill. If these initiatives lead to a reduction in decoding difficulties, fewer children may exhibit the dyslexia and mixed difficulty profile.

2.4 Classification of Reading Difficulties

Children who exhibit reading difficulties are not a homogeneous group. Researchers have developed classification systems that have attempted to explain the variation within the lower end of the reading distribution. This section focuses on the five main approaches that have been used to classify children with reading difficulties. The first of these approaches is referred to as the IQ discrepancy approach. For many years this was one of the most commonly applied classification approaches. It posited that poor readers could be classified into those displaying a discrepancy between IQ and reading achievement and those who do not show this discrepancy (Catts et al., 2003; Savage, 2001).

Research has found that IQ discrepant and IQ non-discrepant poor readers have the same core decoding difficulties (Savage, 2001). Hurford et al. (1993) classified 209 first-grade children according to their reading ability and intelligence. Children who performed above a standard score of 85 (one standard deviation below the mean) on the decoding measure were assigned to the non-disabled group. Children who performed below a standard score of 85 on the decoding measure but above a standard score of 85 on the intelligence measure were assigned to the reading disability group (IQ discrepancy group). Children who performed below a standard score of 85 on both the decoding and the intelligence measures were assigned to the garden-variety poor reader group (no discrepancy). They found that the reading disability group (IQ discrepancy group) and the garden-variety poor reader group (no discrepancy) exhibited the same type of reading difficulties. Both groups performed significantly worse than the non-disabled group on a measure of word reading ability and a measure of phonological awareness. There was also no significant difference between these two groups on these measures. This indicates that both groups exhibited the same type of reading difficulty and performed at a similar level on these reading-related measures, which suggests that their reading difficulties were unrelated to their IQ. The IQ discrepancy approach has now been widely discredited because it demonstrates neither validity nor utility (Catts et al., 2003; Hurford et al., 1993).

Three other approaches have focused on classifying children with decoding difficulties. The first of these approaches is based on the dual route model of reading. This model theorises that words can be decoded through a lexical route, where words are recognised by sight alone. Alternatively, words can be decoded via a sublexical route, where children apply their knowledge of letter–sound relationships and orthographic knowledge to decode words (Pritchard et al., 2018). Evidence for this model has been found in studies that have presented children with non-words, irregular words, and regular words. Non-words are made-up words. They include words such as *yerdle*, *gnobe*, and *knoink*. The dual route model predicts that these words must be read through the sublexical pathway because children have never encountered these words in print. The term irregular word refers to words that include exceptions to spelling rules or letter patterns that represent sounds in unusual ways. Examples of irregular words are *said*, *are*, and *yacht*. The dual route model predicts that these words must be read through the lexical pathway because decoding using the sublexical pathway would result in incorrect pronunciations. Irregular words should be read more slowly than regular words because the lexical and sublexical pathways generate conflicting pronunciations for irregular words but consistent pronunciations for regular words. Research has found that irregular words are read more slowly than regular words. This effect is most noticeable when low-frequency irregular words are used in analyses (Coltheart & Rastle, 1994). More recent studies using computer programs to model decoding have found support for the dual route model (Coltheart et al., 2001; Pritchard et al., 2018). These models have also shown how the lexical and sublexical routes may interact (Pritchard et al., 2018).

While research has found support for the dual route model, there is less evidence that poor decoders can be classified based on their ability to read non-words and irregular words (Murphy & Pollatsek, 1994). This form of classification approach predicts that there should be a negative correlation between tests that rely on these separate routes to decoding. It also predicts that poor readers should fall into one of two clusters based on their performance on these measures. Murphy and Pollatsek (1994) investigated both of these hypotheses in a study with children aged 10–13 years who exhibited reading difficulties. They found that there was not a negative correlation between non-word reading and irregular word reading. In fact, they found these measures correlated closely. Murphy and Pollatsek also found that poor readers did not fall into distinct clusters and were instead distributed continuously across these two variables. Whether children use a lexical or a sublexical pathway is primarily influenced by the frequency with which they have seen the word (Coltheart & Rastle, 1994). These findings indicate that this approach is not a valid method for classifying poor readers.

The second approach, which focused primarily on children with decoding difficulties, proposed that children could be classified as either accuracy-disabled or rate-disabled readers (Lovett, 1987). Research has not found support for this approach. Adlof et al. (2006) followed 604 children from second to eighth grade. They classified children as having a rate deficit if they performed above the 40th percentile on a test of single word reading accuracy and below the 25th percentile on a test of connected text fluency. They found that only 19 children in Grade 8, 36 children in Grade 4, and 34 children in Grade 2 met the rate deficit criteria. However, this reduced to 10, 17, and 13 children, respectively, in each grade when children with listening comprehension scores below the 40th percentile were removed. All of the remaining children had reading comprehension scores in the normal range (above 25th percentile). This suggests that reading comprehension difficulties are not likely to be due to rate deficits alone, which indicates that this is not a valid classification approach.

The third classification approach, referred to as the double-deficit hypothesis, predicted that children could be classified based on their performance on rapid naming and phonological awareness tests. Schatschneider et al. (2002) tested the double-deficit hypothesis by comparing a rate deficit group (*n* = 56) with a phonological deficit group (*n* = 33) and a double-deficit group (*n* = 30). The double-deficit group exhibited both phonological and rapid naming difficulties. Children in these groups were identified from a larger sample of children (*n* = 945) in kindergarten to second grade. The double-deficit hypothesis predicts that children in all three groups should exhibit reading difficulties. Schatschneider and colleagues' results were not consistent with this expectation. The rate deficit group and phonological deficit group fell within the average range on tests that assessed decoding and reading comprehension difficulty. The combined deficit group exhibited greater difficulties on these skills but not all children in this group exhibited reading difficulties.

Intervention studies have also investigated the double-deficit hypothesis. These studies have explored whether instruction that targeted the skill (rate or phonological difficulty) when children exhibited difficulties resulted in improved reading outcomes. Deeney et al. (2001) described a case study in which a child with rapid naming difficulties was provided with a programme that was designed for children who exhibit the rapid naming or double-deficit profile. After providing the child with 70 hours of instruction, the child exhibited improved rapid naming skills. However, on closer inspection it is clear that this child also had phonological difficulties, was taught phonological analysis and blending skills as part of the intervention programme, and made gains in phonological awareness. Therefore, this study does not support the double-deficit hypothesis because the gains that this child made in rapid naming could be due to the phonological instruction they received. Lovett et al. (2000) was able to conduct a double-deficit study with a larger sample of children. The researchers randomly assigned children exhibiting the phonological deficit (*n* = 31), rapid naming deficit (*n* = 33), and double deficit (*n* = 76) to a phonological, metacognitive, or control intervention programme. All groups made gains in phonological awareness and small gains in word reading ability. Rapid naming growth was not identified. According to the double-deficit hypothesis, providing children in the rapid naming deficit group with phonological instruction should not have resulted in improved word reading ability. The results from these studies indicate that the double-deficit hypothesis is not a valid classification approach.

The classification studies described above have focused primarily on the decoding component of reading comprehension. They have not considered what role impaired language comprehension has on reading comprehension difficulties. The SVR hypothesises that difficulties with decoding, language comprehension, or a combination of these difficulties can lead to impaired reading comprehension ability. Because the SVR focuses on both decoding and language comprehension it can be used to accurately classify a greater proportion of struggling readers than classification approaches that focus only on decoding (Aaron et al., 1999; Catts et al., 2003; Ebert & Scott, 2016; Morris et al., 2017). However, the SVR was not designed purely for classification purposes. It is a cognitive model of reading comprehension that predicts that at the coarsest level, reading comprehension can be separated into decoding and language comprehension (Catts, 2018; Hoover & Tunmer, 2018). While the relative importance of these variables changes with age (Catts, Hogan, et al., 2005; Georgiou et al., 2009; Hoover & Gough, 1990), the model predicts that these two variables alone are sufficient to predict reading comprehension proficiency at all age and ability levels.

The following sections describe the SVR in greater detail. Studies that have investigated the SVR are reviewed, and key findings and limitations are discussed.

2.5 Evidence for the SVR

The SVR is now regarded as one of the most fully investigated cognitive models of children's reading comprehension (Kirby & Savage, 2008; Vaughn, 2018). The original paper has been cited nearly 3,000 times and has prompted over 30 subsequent studies, which have investigated various aspects of the SVR (Vaughn, 2018). It has also inspired subsequent models of reading comprehension, including the cognitive foundations framework and the component model of reading comprehension. The cognitive foundations framework elaborates on the lower-level processes that contribute to decoding and language comprehension (Tunmer & Hoover, 2019), and the component model conceptualises the relationship between cognitive, psychological, and ecological components and reading comprehension (Aaron et al., 2008).

Researchers have tested the validity of the SVR using many different approaches (Aaron et al., 2008; Catts et al., 2003; Hoover & Gough, 1990; Lonigan et al., 2018). These approaches have included classification studies, experimental studies, neurological research, and approaches designed to investigate the relationship between decoding and language comprehension. The first study that investigated the relationship between decoding, language comprehension, and reading comprehension was undertaken by Hoover and Gough (1990). They found that decoding and language comprehension explain most of the variance in reading comprehension through multiple regression analyses. Since then, many subsequent studies have confirmed this finding using the same approach (Chen & Vellutino, 1997; Georgiou et al., 2009; Joshi & Aaron, 2000; Savage, 2001, 2006). In more recent years, studies using structural equation modelling (SEM) have found evidence for the SVR. These studies use latent variables, rather than observable variables, which allow the researchers to exclude error variance (Durand et al., 2005). Using this approach, researchers have determined that decoding and language comprehension explain almost all of the variance in reading comprehension (Adlof et al., 2006; Chiu & Consortium, 2018; Foorman et al., 2015; Language and Reading Research Consortium, 2015; Lonigan et al., 2018; Silverman et al., 2013).

The validity of the SVR has also been investigated through classification studies. These studies have determined that it is possible to identify poor readers who exhibit decoding difficulties, language comprehension difficulties, or difficulties with both of these skills (Aaron et al., 1999; Catts et al., 2003; Ebert & Scott, 2016; Morris et al., 2017). This is one of the key predictions made by the SVR. The model also predicts that addressing decoding and/or language comprehension difficulties should lead to improved reading comprehension ability. Aaron et al. (2008) found support for this hypothesis in their research, which included 330 children from Grades 2 to 5. The children in this study who were grouped according to their reading difficulty (decoding or comprehension) and then provided with targeted instruction in this skill made better reading comprehension progress than children with reading difficulties who received undifferentiated instruction.

The SVR predicts that reading difficulties can result from decoding difficulties, language comprehension difficulties, or difficulties with both of these skills. Neurological studies have been able to identify this pattern of difficulties in patients with neurological impairments. This research has found some patients with neurological impairments can comprehend individual words better than they can pronounce them. In contrast, other patients can decode words but cannot comprehend their meaning (Aaron et al., 2008).

2.6 Lower-Level Cognitive Processes

The SVR was not designed to be a complete model of reading comprehension (Tunmer & Chapman, 2012). It focuses only on the cognitive processes that are proximally related to reading comprehension (Hoover & Tunmer, 2018) and does not identify the lower-level cognitive processes that contribute to decoding and language comprehension (Catts, 2018). However, subsequent work by the SVR authors (Tunmer & Hoover, 2019) and others (Wren, 2001) have attempted to elucidate these skills. The following sections describe these lower-level cognitive processes and their relationship to decoding and language comprehension.

2.6.1 Cognitive Processes that Contribute to Language Comprehension

Background knowledge and linguistic comprehension are the two cognitive capacities that underlie language comprehension (Tunmer & Hoover, 2019). Background knowledge refers to the prior knowledge required to make meaning from spoken language. To understand spoken language children must have some prior understanding related to the discourse. Linguistic comprehension can be divided into three domains: phonology, semantics, and syntax (Tunmer & Hoover, 2019; Wren, 2001).

Phonology refers to our ability to hear and distinguish sounds in speech. The smallest meaningful sound units within speech are phonemes. Phonemic identification is particularly important within an alphabetic orthography because phonemes map to graphemes (sounds map to letters). If children cannot identify phonemes within a word, they will not be able to match the sound to the corresponding letter or letter combination. Children can experience difficulty identifying phonemes within the acoustic signal stream produced by speech (Tunmer & Hoover, 2019). Inaccurate identification of a phoneme can lead to retrieval errors from a child's mental lexicon (Tunmer & Hoover, 2019). For example, inaccurately identifying the /d/ sound in *mad* as a /t/ sound will prompt retrieval of an incorrect word from the child's lexicon (*mat*).

Syntactic knowledge is an awareness of rules that dictate how words can be combined to create larger units of meaning. In addition to understanding that words carry meaning, listeners must understand the system that dictates how words can be arranged. While listening, they must monitor the relationship between the words to develop a mental representation of the utterances (Tunmer & Hoover, 2019). Some examples of simple English syntax conventions are matching tense and number, using the correct article, using the correct pronoun, and placing words in the correct order. For example, in English we can say "Sam hit the ball". This sentence follows a subject (Sam), verb (hit), object (ball) sequence. It would be syntactically incorrect to say "Sam ball the hit". However, this structure (subject-object-verb) is acceptable in other languages, such as Japanese (Shibatani et al., 2017).

Semantics is concerned with meaning. Meaning occurs within three levels of language. The first level includes morphemes, which are the smallest units of speech that carry meaning. Morphemes occur within words. Some words, such as *break*, contain only one morpheme. However, other words, such as *unbreakable*, are composed of a number of morphemes. The first morpheme /*un*/ means not, /*break*/ is the root morpheme, and the final morpheme /*able*/ means capable of. Knowledge of these morphemes aids comprehension. If an object is referred to as unbreakable, the listener knows it means that the object is not capable of being broken. Words are the next largest unit that carry meaning. Many SVR studies recognise the importance of vocabulary by using composite language comprehension variables that are based, in part, on vocabulary knowledge (Aaron et al., 1999; Catts et al., 2003; Ebert & Scott, 2016; Morris et al., 2017). Although vocabulary knowledge is positioned within the semantics branch of linguistic comprehension on the language comprehension side of the model, it also plays an important role in decoding.

Readers are more likely to decode a new or unfamiliar word if they have a strong mental representation of that word in their mind (Nation & Snowling, 1998, 2004; Share, 1999). Share (1999) found evidence for this in a study with 40 typically achieving second grade children. The children were asked to read aloud short texts that included some made-up words. After three days, children were presented with four words for each passage. These words included the original word and three alternate spellings of the word they had read in the short passages. They were presented with the original target spelling, a homophonic spelling of the word, a word with a letter substitution, and a word with a letter transposition. Target words that matched the target pronunciation were chosen more frequently than phonologically incorrect spellings, which indicates that phonological learning has occurred, and the correct word was chosen more frequently than the incorrect homophonic alternative, thus indicating orthographic learning. In a subsequent task, the children read the correctly spelled target words more quickly than the homophonic foils. These results indicate that vocabulary knowledge plays an important role in word recognition.

Two studies conducted by Nation and Snowling (1998, 2004) also found that vocabulary plays a role in word recognition. In a sample of 72 children aged 8.5 to 13.0 years, Nation and Snowling (2004) found that vocabulary knowledge accounted for additional variance in word recognition ability after accounting for age, non-verbal ability, non-word reading ability, and phonological skills. In an earlier study, Nation and Snowling (1998) found that vocabulary knowledge influenced reading accuracy and reading speed. Their study included 16 children with poor vocabulary knowledge who were matched for decoding skill, age, and non-verbal ability with 16 typically achieving peers. Nation and Snowling (1998) found that children with poor vocabulary knowledge read low-frequency irregular words more slowly than typically achieving children and made more errors when reading these words. These results indicate that vocabulary knowledge facilitates skilled decoding.

The third and final level of meaning includes sentences and discourse. Listeners begin to construct mental representations of sentences as soon as word meanings are retrieved from their mental lexicon. Sometimes these mental representations must be revisited when the content differs from what was expected. Examples of this can be found in eye tracking studies conducted by Ni et al. (1998) and Pearlmutter et al. (1999). Ni and colleagues provided 24 English-speaking college students with 30 sets of sentences. In each set, one sentence was both syntactically and semantically correct (e.g. "It seems that the cats won't usually eat the food we put on the porch."). The other sentences were either syntactically incorrect ("It seems that the cats won't usually eating the food we put on the porch.") or semantically incorrect ("It seems that the cats won't usually bake the food we put on the porch."). The syntactically and semantically incorrect sentences resulted in more regressive eye movements than the syntactically and semantically correct sentences. A similar result was observed in the study conducted by Pearlmutter et al. (1999). They presented 83 college students with sets of sentences in which there was subject–verb agreement in only one of the sentences (e.g. "The key to the cabinet was/were rusty from many years of disuse."). The participants made more eye movement regressions when there was not subject–verb agreement.

Within larger units of discourse the listener must integrate meaning from the sentence that has just been processed with previous sentences within the discourse and the listener's own prior knowledge about the topic. Difficulty constructing meaning at the morpheme, word, or sentence/discourse level can lead to impaired comprehension of spoken language. In a study with children similar in age to those in the current research (8 years old), Nation et al. (2004) found that poor comprehenders exhibited greater morphosyntactic, vocabulary, and receptive and expressive language difficulties than their typically developing peers. Subsequent research has shown that remediating these difficulties can lead to improved reading comprehension (Clarke et al., 2010; Nation et al., 2004). Clarke et al. (2010) found that children (8 years old) with a comprehension impairment who received a programme that focused on oral language skills made significant reading comprehension gains that were maintained over time.

Children typically learn their native language without the need for explicit instruction (Wren, 2001). They learn through frequent exposure to language from birth. This exposure is sufficient for most typically developing children to develop functional literacy skills. Typically developing children begin to use single words when they are around 12–18 months old. By 18–30 months most children can combine these words into simple three-word combinations, and by 30–48 months most children can create simple sentences. Prior to starting school, most children have relatively large vocabularies. They can use these vocabularies and their knowledge of grammatical conventions to communicate a wide range of topics (Tager-Flusberg et al., 2009). However, in some instances, the verbal interactions children are exposed to are not sufficient to develop the more advanced skills that are required for formal language, such as those used within academic settings (Tunmer & Hoover, 2019; Wren, 2001). For example, many children are likely to encounter vocabulary in written text that they have not encountered in oral conversations (Beck et al., 2013). Limited vocabulary knowledge can be addressed through targeted classroom instruction (Beck & McKeown, 2007). Beck and McKeown (2007) found that children in kindergarten and first grade who were provided with explicit vocabulary instruction learned significantly more sophisticated words, such as those they might encounter in text, than controls who received no instruction.

2.6.2 Cognitive Processes that Contribute to Decoding

The other side of the SVR model focuses on decoding. Instant and accurate word recognition is essential for reading comprehension. Inaccurate decoding may lead to the incorrect word being retrieved from the reader's mental lexicon, and inefficient word reading places increased demands on the reader's cognitive abilities, which may impede comprehension. The SVR authors (Tunmer & Hoover, 2019) have attempted to identify the lower-level cognitive processes that contribute to this side of the model. The skill that underpins decoding is alphabetic coding. This is the ability to match letter sounds (phonemes) to letter patterns (graphemes). It also includes the knowledge of rules that dictate how phonemes are related to graphemes. For example, the reader must know that the letter *c* makes the /*s*/ sound when it precedes an *i*, *e*, or *y*. One of the difficulties associated with learning the alphabetic code is the transparency of the orthography. Languages such as Spanish and Greek have relatively transparent orthographies (Diamanti et al., 2018; Ehri, 2014). This means that phonemes map to graphemes in a consistent way. In contrast, English is regarded as a more opaque orthography because there is less consistency between phoneme–grapheme relationships (Vellutino et al., 2004). As a result, children may take longer to develop alphabetic coding skills in English than in other more transparent orthographies (Vellutino et al., 2004). Notwithstanding these differences, 80% of monosyllabic words in English can be pronounced using a small number of phoneme to grapheme rules. The remaining words typically have only one grapheme that differs from its most common pronunciation (Castles et al., 2018). This level of consistency fosters the development of alphabetic coding skills.

To develop alphabetic decoding skills, children must have letter knowledge and phoneme knowledge. Letter knowledge is simply the ability to identify and manipulate the symbols that are used in the writing system (Tunmer & Hoover, 2019; Wren, 2001). This includes the ability to identify upper case and lower case letters and letters in different fonts. Knowledge of letter names can support the development of phoneme awareness (Tunmer & Hoover, 2019). Most letter names contain the phoneme represented by the letter. For example, the letter *d* is composed of two phonemes (/d/, /e/). The first phoneme represents the sound made by the letter. Letter names can also be used to support attempts by beginning readers to write words. A child who is learning to encode using the alphabetic principle may represent the word *bay* as *ba*. In this example, the child has used the correct letter for the first phoneme and has represented the second phoneme with a letter name.

Phonemic awareness is the ability to identify and manipulate the smallest units of sound that make up words (Tunmer & Hoover, 2019; Wren, 2001). For most children phonemic awareness must be explicitly taught, and this instruction typically first occurs at school (Tunmer & Hoover, 2019; Wren, 2001). Phonemic awareness is a prerequisite for skilled decoding and encoding. If children can identify the three phonemes within *cat*, they know that three graphemes will be required to represent these sounds. For most children, phonemic awareness improves greatly once they begin to interact with text (Bishop & Snowling, 2004). Phonemic awareness appears to be particularly important for the development of skilled decoding. Many studies have shown that programmes that focus on phonemic awareness lead to improved decoding outcomes (Arrow, 2018; Carson et al., 2013; Gillon et al., 2019; National Institute of Child Health and Human Development, 2000).

Letter knowledge and phonemic knowledge alone are not sufficient for alphabetic decoding. Children must also have knowledge about print conventions. First, children must understand that print carries meaning and that ideas expressed using spoken words can be represented in text. Children must develop an awareness that, within English, text runs left to right and from the top of the page to the bottom of the page. They must understand that spaces within these sentences are used to mark the gaps between words, and when text spans across multiple pages children must be aware that these texts are read from the front to the back. Children from text-rich home environments often develop this knowledge without explicit instruction (Wren, 2001).

While children, typically, learn their native language without formal instruction, the same is not true for decoding. The ability to decode text is a skill that requires explicit instruction. To become proficient decoders, children require programmes that are systematic, explicit, and structured (Arrow, 2018; Arrow & Tunmer, 2012). Systematic programmes follow a scope and sequence. This means that features of the English writing system are taught, and new skills and knowledge are designed to build on previously mastered skills. Explicit programmes clearly communicate what skill is being taught. A structured programme provides children with opportunities to review previously learnt skills, learn and practise new skills, and apply these skills with text, and then provides further practice opportunities.

Once children begin to understand the alphabetic principle they start to independently apply this skill within texts (Castles et al., 2018). A developmental theory of reading (Ehri, 2014) suggests that children move through a partial alphabetic phase during which they apply their limited collection of skills to decode words. With further instruction, children move through a full alphabetic phase when they demonstrate greater competency applying a broader range of knowledge about phoneme–grapheme relationships to decode unfamiliar words (Ehri, 2014). This allows them to access the meaning of these words from their mental lexicon (Castles et al., 2018). With additional practice, the fluency with which these skills are applied improves to the point where a greater number of words are instantly identified (Castles et al., 2018). Share (1999) proposed the self-teaching hypothesis to describe how children might apply their alphabetic decoding skills to read new and unfamiliar words. This theory postulates that by repeatedly applying alphabetic decoding skills, children acquire orthographic knowledge, which they can apply to facilitate rapid word reading, reducing the need for an alphabetic decoding approach. Orthographic knowledge includes knowledge about spelling patterns, spelling rules, and other word-specific knowledge (Castles et al., 2018; Otaiba et al., 2012). As few as four exposures may be sufficient to develop orthographic learning in typically developing readers (Share, 1999).

2.7 SVR Meta-Analysis

The SVR focuses on decoding and language comprehension, the two factors that are proximally related to reading comprehension. The model predicts that the relationship between decoding and language comprehension is multiplicative (Gough & Tunmer, 1986; Hoover & Gough, 1990). This means that neither decoding nor language comprehension alone can be sufficient for reading comprehension. Within the SVR equation, decoding and language comprehension proficiency can range from 0 to 1, where 0 represents no ability and 1 represents perfection (Gough & Tunmer, 1986). Conceptually, a multiplicative model makes sense when considering children who have no decoding or language comprehension ability. In these cases, a sum model predicts that these children will still have some level of reading comprehension ability. A multiplicative model places a greater penalty on incomplete knowledge. Children who have no decoding ability are predicted to have some reading comprehension ability within an additive model. In contrast, these children are predicted to have no reading comprehension ability within a multiplicative model.

The first study that investigated the relationship between decoding, language comprehension, and reading comprehension was conducted in 1990 by Hoover and Gough. They found that decoding and language comprehension explained most of the variability in reading comprehension. Gough and Tunmer (1986) predicted that the relationship between decoding and language comprehension would be multiplicative. Hoover and Gough were unable to confirm this relationship. They found that a model based on the linear combination of decoding and language comprehension could be improved by adding the multiplicative term (decoding × language comprehension). This model was a significant improvement on models that included only a linear combination of decoding and language comprehension, as well as a significant improvement on a multiplicative only model. The authors noted that their finding might be influenced by the approach they used to investigate the relationship between these variables. Regression combines decoding and language comprehension with optimal weights to maximise the least squares fit to the reading comprehension data. The components in a multiplicative approach cannot be weighted in this way, which makes for an unfair comparison. Despite this limitation, other studies have investigated the relationship between these variables using the same approach (Chen & Vellutino, 1997; Georgiou et al., 2009; Joshi & Aaron, 2000; Savage, 2006). Chen and Vellutino (1997) and Savage (2006) found that a linear combination alone explained a greater proportion of the variance in reading comprehension than a multiplicative approach. However, Georgiou et al. (2009) and Joshi and Aaron (2000) found little difference between these approaches.

All previous SVR studies have found that decoding and language comprehension play an important role in reading comprehension. Some studies have investigated whether additional variables need to be added to the SVR model to provide a more complete account of reading comprehension ability. The variables that have been investigated include processing speed (Aaron et al., 2008; Johnston & Kirby, 2006; Joshi & Aaron, 2000; Tiu et al., 2003), intelligence (Tiu et al., 2003), phonological awareness (Johnston & Kirby, 2006), vocabulary knowledge (Tilstra et al., 2009), and reading fluency (Tilstra et al., 2009). Multiple regression research has not consistently identified a variable that improves the predictive utility of the model. Care must be taken when interpreting these studies because of methodological limitations. Multiple regression analyses investigate the relationship between observable independent variables and an observable dependent variable. All of these variables are measured with some degree of error. A more advanced approach uses latent variables to investigate the relationship between decoding, language comprehension, and reading comprehension. Latent variables are not directly observable. Instead, they are inferred from other observable variables. They are also free from test-specific error variance (Lonigan et al., 2018). The use of latent variables allows researchers to capture the breadth of a construct. Recent studies have used this approach to investigate the SVR. They have found that almost all the variation in reading comprehension can be explained by decoding and language comprehension ability (Adlof et al., 2006; Chiu & Consortium, 2018; Foorman et al., 2015; Language and Reading Research Consortium, 2015; Lonigan et al., 2018).

Many studies have investigated the SVR using multiple regression analyses. Far fewer studies have investigated the SVR using SEM analyses. This means it is possible to find a much larger number of studies that have investigated certain aspects of the SVR using multiple regression than those using SEM analyses. This section combines studies that have used multiple regression analyses within a meta-analysis. Combining studies in a meta-analysis increases statistical power. It also weights studies, which means that studies with larger samples provide a greater contribution to the overall effect size. Because studies are combined and findings are based on a large sample of participants, the findings are more likely to be representative of the true effect within the population than the results obtained in one study. This meta-analysis was used to investigate the following questions: (1) What proportion of the variance in reading comprehension can be accounted for by decoding and language comprehension ability? (2) Does the variance in reading comprehension explained by the SVR differ between groups of mixed ability children and struggling readers? (3) Does the age of the participants (measured in school grade) moderate the relationship between reading comprehension and a combined measure of decoding and language comprehension?

(4) Does the way the decoding variable is operationalised within studies moderate the relationship between reading comprehension and a combined measure of decoding and language comprehension?

Relevant studies were identified through a search of English peer-reviewed journals in the PsycINFO and ERIC databases using the terms “simple view of reading” and “component model of reading”. The search was limited to studies published since 1986, the year the SVR was published by Gough and Tunmer. Respectively, the PsychINFO and ERIC database searches identified 129 and 65 possible studies. Some studies were identified in both searches. These duplicate studies were removed and the remaining studies were reviewed.

Only studies that included English-speaking children were included in these analyses. Previous research has found that the complexity of an orthography affects reading development (Diamanti et al., 2018). The relative importance of cognitive factors also varies across orthographies. For example, learning to read in Indian languages places a greater demand on visual processing skills than alphabetic orthographies (Chang et al., 2018). Because a meta-analysis aims to combine effect sizes from a range of similar studies, it was appropriate to exclude studies that were not conducted in English with English-speaking children.

There is a general consensus in the literature that the ability to decode words and the ability to understand spoken language are the two factors most closely associated with reading comprehension (Chiu & Consortium, 2018; Foorman et al., 2015; Lonigan et al., 2018). Notwithstanding this finding, the relative importance of these two variables is known to change over time (Catts, Hogan, et al., 2005) and the total variance in reading comprehension ability explained by these variables decreases from primary and secondary to college-aged students (Gough et al., 1996). This means there is likely to be a number of true effect sizes if a meta-analysis was conducted on studies that were not restricted to a particular age range. To maximise the homogeneity of the studies, this research focused on studies that included children. Studies that included adults were excluded from these analyses.

To be included in these analyses, studies had to report at least one correlation (*r*) between any measure of reading comprehension ability and a combined measure of decoding and language comprehension ability. Studies that reported the percentage of variance (r^2) in reading comprehension accounted for by the combined measure of decoding and language comprehension ability were also included in this research. When only the r^2 value was provided, it was transformed to the corresponding correlation. Fifteen studies met all of the selection criteria. In total, these studies reported 105 effect sizes. The following paragraphs describe additional criteria that had to be met for a study to be included in an analysis. These paragraphs also describe the rationale that underpinned these analyses in greater detail.

The first analysis investigated what proportion of the variance in reading comprehension could be accounted for by decoding and language comprehension ability. To be included in the analysis the studies had to include mixed ability children. When studies reported separate correlations for different reading comprehension measures, the largest correlation was used. The largest correlation was also used when studies included separate correlations for a multiplicative interaction and an additive interaction. The analysis included 31 effect sizes from 15 studies.

The *Q*-statistic confirmed that the studies did not share one common effect size, $Q(30) = 162.920$, $p < .001$. Therefore, the results for a mixed effects analysis are presented here. The mean correlation was .790 with a lower confidence interval of .752 and an upper confidence level of .822. This indicates that between 57% and 68% of the variance in reading comprehension can be accounted for by decoding and language comprehension (see Figure

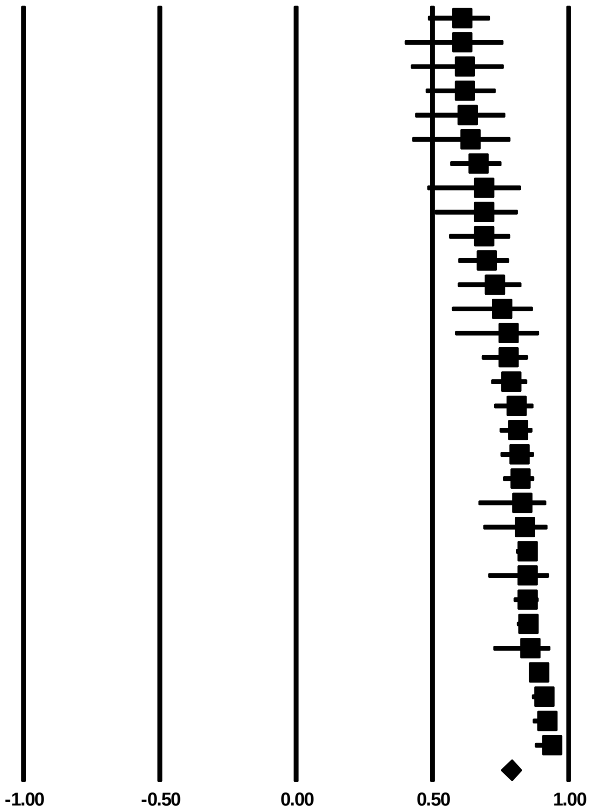
2.1). These results confirm that decoding and language comprehension explain most of the variance in reading comprehension.

Figure 2.1

Proportion of Variance Explained

Study name	Subgroup within study	Correlation	Lower limit	Upper limit	Z-Value	p-Value
Neuhaus et al (2006) Grade 3	Linear	0.610	0.485	0.711	7.733	0.000
Aaron, Joshi, Gooden & Bentum (2008) Grade 2	Product	0.610	0.399	0.759	4.860	0.000
Aaron, Joshi, Gooden & Bentum (2008) Grade 3	Product	0.620	0.422	0.761	5.178	0.000
Tilstra, McMaster, Van den Broek, Kendeou & Rapp (2009) Grade 9	Linear	0.620	0.476	0.731	6.878	0.000
Aaron, Joshi, Gooden & Bentum (2008) Grade 4	Product	0.630	0.438	0.767	5.346	0.000
Aaron, Joshi, Gooden & Bentum (2008) Grade 5	Product	0.640	0.427	0.786	4.914	0.000
Dreyer (1992) Grade 3	Combined	0.670	0.566	0.753	9.385	0.000
Joshi & Aaron (2000) Grade 3	Product	0.690	0.482	0.824	5.158	0.000
Georgiou, Das & Hayward (2009) Grade 3	Linear	0.690	0.510	0.812	5.813	0.000
Tilstra, McMaster, Van den Broek, Kendeou & Rapp (2009) Grade 7	Linear	0.690	0.563	0.785	7.864	0.000
Dreyer (1992) Grade 5	Combined	0.700	0.596	0.781	9.421	0.000
Connors (2008) Grade 3	Combined	0.730	0.594	0.825	7.430	0.000
Chen & Vellutino (1997) Grade 7	Product	0.756	0.572	0.868	5.754	0.000
Aaron (1991) Grade 8	Linear	0.780	0.584	0.890	5.432	0.000
Tilstra, McMaster, Van den Broek, Kendeou & Rapp (2009) Grade 4	Linear	0.780	0.683	0.850	9.694	0.000
Johnston & Kirby (2006) Grade 4	Product	0.790	0.716	0.846	12.263	0.000
Spear-Swerling (2004) Grade 4	Linear	0.810	0.727	0.870	10.810	0.000
Chen & Vellutino (1997) Grade 6	Linear	0.815	0.747	0.866	12.816	0.000
Johnston & Kirby (2006) Grade 5	Product	0.820	0.750	0.872	12.405	0.000
Chen & Vellutino (1997) Grade 3	Linear	0.824	0.760	0.872	13.227	0.000
Aaron (1991) Grade 7	Linear	0.830	0.670	0.916	6.174	0.000
Aaron (1991) Grade 6	Linear	0.840	0.688	0.921	6.345	0.000
Hoover & Gough (1990) Grade 1	Linear	0.850	0.808	0.884	18.073	0.000
Aaron (1991) Grade 3	Linear	0.850	0.706	0.927	6.527	0.000
Johnston & Kirby (2006) Grade 3	Product	0.850	0.799	0.889	15.333	0.000
Hoover & Gough (1990) Grade 2	Linear	0.853	0.811	0.886	18.053	0.000
Aaron (1991) Grade 5	Linear	0.860	0.724	0.932	6.720	0.000
Chen & Vellutino (1997) Grade 2	Linear	0.892	0.856	0.920	18.109	0.000
Hoover & Gough (1990) Grade 3	Product	0.911	0.866	0.941	13.970	0.000
Hoover & Gough (1990) Grade 4	Linear	0.922	0.869	0.954	11.554	0.000
Aaron (1991) Grade 4	Linear	0.940	0.877	0.971	9.031	0.000
		0.790	0.752	0.822	22.627	0.000

Correlation and 95% CI



The second analysis examined two groups of children: mixed ability and struggling readers. It investigated whether the variance in reading comprehension explained by the SVR differed between these groups. To be included in this analysis, studies had to report the results for either mixed ability children or struggling readers. This analysis used the largest correlation reported in a study when different reading comprehension measures were reported, when separate correlations were provided for word attack and word identification measures, and when separate multiplicative and additive analyses were reported. Two studies reported results for a mixed group and a poor reader group (Georgiou et al., 2009; Johnston & Kirby, 2006). However, these groups were not independent. The children assigned to the poor reader groups in these studies were also included in the mixed group analyses. For this reason, only the poor reader groups from these studies were included in this analysis. The analysis included 32 effect sizes from 13 studies.

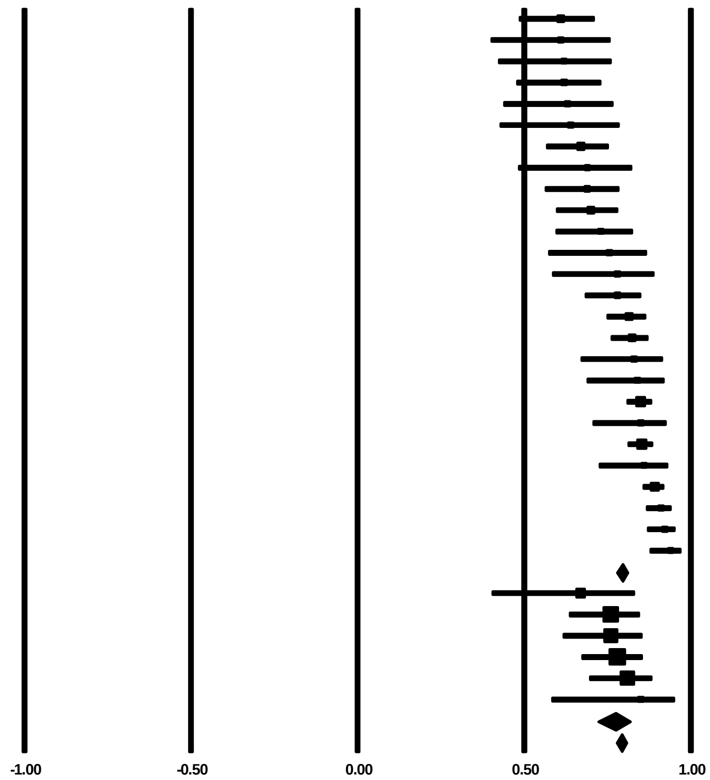
The Q-statistic indicated that the studies that included poor readers shared a common effect size, $Q(5) = 2.455$, $p = .783$. In contrast, the heterogeneity analysis for the studies that included mixed ability readers indicated that these studies did not share a common effect size, $Q(25) = 155.170$, $p < .00$. Therefore, the subsequent analyses are based on a mixed effects analysis. The mean correlation for the mixed ability studies was 0.788 and the mean correlation for the studies that included only poor readers was 0.773. This means that respectively, 62%, $z = 18.746$, $p < .00$, and 60%, $z = 17.033$, $p < .00$, of the variance in reading comprehension could be accounted for by these approaches (see Figure 2.2). There was no significant difference between these groups of studies, $Q(1) = .211$, $p = .646$. This finding, together with the results reported in Table 2.1, suggests that research on whole-cohort and subgroups of readers can be performed and produce similar levels of explanation. If a far smaller proportion of the variance in reading comprehension was explained in the poor reader group, it might indicate that the SVR did not provide a complete account of their reading difficulties. The results from this analysis indicate that it is unlikely that the difficulties poor readers' exhibit are due to some other variable not included in the model.

Figure 2.2

Proportion of Variance Explained (Mixed Ability v Struggling Readers)

Study name	Subgroup within study	Statistics for each study				
		Correlation	Lower limit	Upper limit	Z-Value	p-Value
Neuhaus et al (2006) Grade 3	Mxed	0.610	0.485	0.711	7.733	0.000
Aaron, Joshi, Gooden & Bentum (2008) Grade 2	Mxed	0.610	0.399	0.759	4.860	0.000
Aaron, Joshi, Gooden & Bentum (2008) Grade 3	Mxed	0.620	0.422	0.761	5.178	0.000
Tilstra, McMaster, Van den Broek, Kendeou & Rapp (2009) Grade 9	Mxed	0.620	0.476	0.731	6.878	0.000
Aaron, Joshi, Gooden & Bentum (2008) Grade 4	Mxed	0.630	0.438	0.767	5.346	0.000
Aaron, Joshi, Gooden & Bentum (2008) Grade 5	Mxed	0.640	0.427	0.786	4.914	0.000
Dreyer (1992) Grade 3	Mxed	0.670	0.566	0.753	9.385	0.000
Joshi & Aaron (2000) Grade 3	Mxed	0.690	0.482	0.824	5.158	0.000
Tilstra, McMaster, Van den Broek, Kendeou & Rapp (2009) Grade 7	Mxed	0.690	0.563	0.785	7.864	0.000
Dreyer (1992) Grade 5	Mxed	0.700	0.596	0.781	9.421	0.000
Connors (2008) Grade 3	Mxed	0.730	0.594	0.825	7.430	0.000
Chen & Vellutino (1997) Grade 7	Mxed	0.756	0.572	0.868	5.754	0.000
Aaron (1991) Grade 8	Mxed	0.780	0.584	0.890	5.432	0.000
Tilstra, McMaster, Van den Broek, Kendeou & Rapp (2009) Grade 4	Mxed	0.780	0.683	0.850	9.694	0.000
Chen & Vellutino (1997) Grade 6	Mxed	0.815	0.747	0.866	12.816	0.000
Chen & Vellutino (1997) Grade 3	Mxed	0.824	0.760	0.872	13.227	0.000
Aaron (1991) Grade 7	Mxed	0.830	0.670	0.916	6.174	0.000
Aaron (1991) Grade 6	Mxed	0.840	0.688	0.921	6.345	0.000
Hoover & Gough (1990) Grade 1	Mxed	0.850	0.808	0.884	18.073	0.000
Aaron (1991) Garde 3	Mxed	0.850	0.706	0.927	6.527	0.000
Hoover & Gough (1990) Grade 2	Mxed	0.853	0.811	0.886	18.053	0.000
Aaron (1991) Grade 5	Mxed	0.860	0.724	0.932	6.720	0.000
Chen & Vellutino (1997) Grade 2	Mxed	0.892	0.856	0.920	18.109	0.000
Hoover & Gough (1990) Grade 3	Mxed	0.911	0.866	0.941	13.970	0.000
Hoover & Gough (1990) Grade 4	Mxed	0.922	0.869	0.954	11.554	0.000
Aaron (1991) Grade 4	Mxed	0.940	0.877	0.971	9.031	0.000
		0.793	0.777	0.809	49.277	0.000
Georgiou, Das & Hayward (2009) Grade 3	Poor	0.670	0.402	0.832	4.134	0.000
Johnston & Kirby (2006) Grade 4	Poor	0.760	0.635	0.846	7.907	0.000
Johnston & Kirby (2006) Grade 5	Poor	0.760	0.616	0.855	7.044	0.000
Johnston & Kirby (2006) Grade 3	Poor	0.780	0.672	0.856	8.870	0.000
Savage (2006) Grade 10	Poor	0.810	0.695	0.885	8.205	0.000
Savage (2001) Grade 10	Poor	0.850	0.582	0.951	4.166	0.000
		0.773	0.721	0.816	17.033	0.000
		0.791	0.775	0.806	52.131	0.000

Correlation and 95% CI



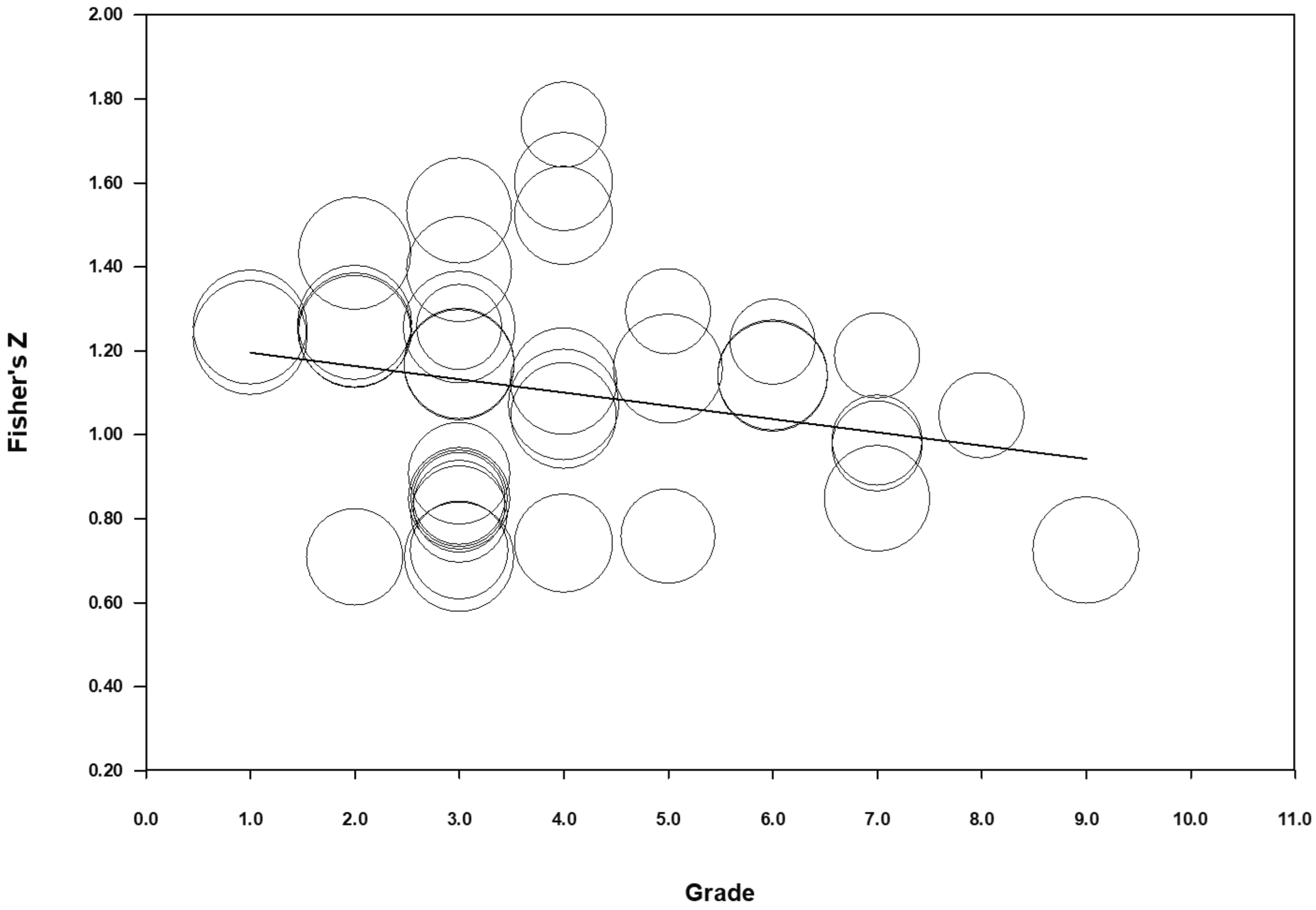
The third analysis investigated whether the age of the children (measured in school grade) moderated the relationship between reading comprehension and a combined measure of decoding and language comprehension. To be included in this analysis, studies had to include mixed ability children. As in previous analyses, this analysis used the largest correlation reported in a study when different reading comprehension measures were reported, when separate correlations were provided for word attack and word identification measures, and when separate multiplicative and additive analyses were reported.

A meta-regression analysis was conducted to determine whether age (measured in school grade) moderated the relationship between reading comprehension and a combined measure of decoding and language comprehension. The analysis indicates that adding age improves the predictive utility of the model. Age explained 13% of the between-study variance in effect sizes; Figure 2.3 shows the relationship. The y-axis is measured in Fisher's *z* scores. The Fisher's *z* transformation converts the sample distribution of the correlation to an approximately normal distribution to facilitate comparisons. The x-axis is measured in school grades. Figure 2.3 shows that most SVR studies tend to be conducted with younger children. The relationship between grade and effect size may be due to difficulties operationalising variables with older children. In younger children it may be possible to accurately assess decoding ability using only word attack and word identification measures. However, in samples with older children it may be necessary to also assess reading fluency. Fluency measures have been found to explain additional variance in reading comprehension than that explained by accuracy-only measures (Kershaw & Schatschneider, 2012; Tilstra et al., 2009). Reading comprehension measures place less demand on children's language comprehension ability in younger grades. However, in older grades far greater demands are placed on children's language comprehension ability because of the increased text complexity (Catts, Hogan, et al., 2005; Language and Reading Research Consortium, 2015).

This means it may be more difficult to accurately assess and match measures of reading comprehension and language comprehension ability in studies with older children. Accurately assessing and matching these measures is an essential component of SVR research (Hoover & Tunmer, 2018).

Figure 2.3

Regression of Fisher's Z on Grade



The final analysis investigated whether the way the decoding variable was operationalised within studies moderated the relationship between reading comprehension and a combined measure of decoding and language comprehension. To be included in this analysis, studies had to include mixed ability children. This analysis used the largest correlation reported in a study when different reading comprehension measures were provided and when separate multiplicative and additive analyses were reported.

The Q-statistics confirmed that neither studies that used a word attack measure, $Q(26) = 129.579$, $p < .00$, nor studies that used a word identification measure, $Q(8) = 40.086$, $p < .00$, shared a common effect size. Therefore, the following results are based on a mixed effects analysis. The mean correlation for the studies that used a word attack measure was 0.778. This means that 61%, $z = 20.937$, $p < .00$, of the variance in reading comprehension could be accounted for by studies using this assessment approach. The mean correlation for the studies using a word identification measure was .802. This means that a slightly larger proportion of the variance was accounted for using this approach (64%). However, this difference was not found to be significant $Q(1) = .587$, $p = 0.444$. Most of the SVR studies focused on children in younger grades at school. It is possible that this influenced the results obtained in this analysis. Tunmer and Chapman (2012) stated that when children are just learning to read, decoding should be assessed through word attack measures. However, as children become more proficient readers, their decoding ability should be assessed using tests that assess word identification ability.

The results from this meta-analysis are consistent with previous findings that decoding and language comprehension explain most of the variance in reading comprehension. This meta-analysis indicates that decoding and language comprehension explained between 57% and 68% of the variance in reading comprehension in studies that investigated this relationship through multiple regression analyses. The inclusion of mixed ability or struggling readers did not influence the proportion of variance in reading comprehension that was explained by decoding and language comprehension. Whether the decoding variable was operationalised through a word attack or word identification test did not influence the proportion of variance in reading comprehension that was explained. However, this finding should be interpreted cautiously because most studies included children in the early school grades. Subsequent analyses indicated that grade influenced the proportion of variance in reading comprehension that was explained by decoding and language comprehension. It is possible that this finding is due to greater difficulties in operationalising the decoding and language comprehension variables in studies with older participants.

2.8 SVR Classification Studies

The previous section focused on studies that have investigated the SVR using multiple regression analyses. These studies have examined the SVR contention that variance in reading comprehension can be explained by decoding and language comprehension. However, that is not the only SVR contention. The SVR also predicts that poor readers can be classified based on their decoding and language comprehension ability into one of three poor reader groups. SVR classification studies have attempted to test this hypothesis.

Four previous studies have used the SVR to classify poor readers (Aaron et al., 1999; Catts et al., 2003; Ebert & Scott, 2016; Morris et al., 2017). The first classification studies were conducted by Aaron and colleagues (1999). In their paper, they reported the results for a principal components analysis (Study 1) and three different classification studies (Studies 2–4). Each classification study had slightly different participant selection criteria. However, they all included a relatively small number of participants (n = 11–16) from the early to late primary grades. All the children either were performing one standard deviation below the mean on a test of reading comprehension (Studies 2 and 3) or came from a remedial reading programme (Study 4). The children were classified according to their performance on a range of decoding and language comprehension measures. If children performed one standard deviation below the mean on one of the tests that assessed decoding ability or language comprehension ability they were identified as exhibiting difficulties in that area. Therefore, a child could be deficient in decoding (dyslexia), language comprehension (SCD), decoding and language comprehension (mixed difficulty), or neither of these variables (unexplained). The proportion of children who fell in each category varied considerably between the studies. It is likely that this variation was due to the small number of participants who were included in each study. While the results indicate that most struggling readers can be assigned to one of the three poor reader categories predicted by the SVR, it is less clear what proportion of all poor readers might fall in each category from the results reported in these studies. For example, in Study 2, only 17% of the children (2 out of the 12 children) were assigned to the dyslexia category. In contrast, 64% of children (7 out of 11 children) were assigned to this category in Study 4.

Catts and colleagues (2003) conducted the largest SVR classification study. This study included 183 participants who were followed from kindergarten to fourth grade. These participants were also taking part in a longitudinal study investigating language impairments in children. Therefore, many of these children had language impairments in addition to performing one standard deviation below the mean on a test of reading comprehension ability. These children completed a number of tests that assessed their decoding, language comprehension, reading comprehension, and phonological awareness. They were then classified according to their performance on the decoding and language comprehension variables when they were in second grade. Both of these variables were composed of multiple tests. For example, a word identification and a word attack test contributed to the decoding variable, and vocabulary, grammar, and narration tests contributed to the language comprehension variable. The researchers defined poor performance in decoding and language comprehension as a *z* score of less than −1 (one standard deviation below the mean). Poor readers with adequate language comprehension and poor decoding were classified as having dyslexia. Children who performed poorly on both the decoding and the language comprehension variables were assigned to the mixed difficulty group. Poor readers who demonstrated adequate performance on the decoding variable but poor performance on the language comprehension variable were assigned to the SCD group. Finally, poor readers who demonstrated adequate performance on the decoding and language comprehension variables were assigned to the unexplained poor reader category. Catts and colleagues found that, in Grade 2, 35.5% of children fell in the dyslexia group, 15.4% fell in the SCD group, 35.7% fell in the mixed difficulty group, and 13.4% fell in the unexplained group.

Catts and colleagues (2005) followed the same group of children from kindergarten to Grade 8. This allowed them to investigate the stability of the poor reader groups over time. They found that the proportion of poor readers who fell in the dyslexia group decreased over time, from 32% in Grade 2 to 13% in Grade 8. During the same period, the proportion of children who fell in the SCD group increased from 16% to 30%. The authors noted that this change was not due to poor readers changing in group placement. Instead, they found that although the children exhibited a similar profile over time, by eighth grade some of the children with dyslexia were no longer classified as poor readers. In contrast, it was not until eighth grade that some readers, who exhibited language comprehension difficulties in Grade 2, met the poor reader criteria. This finding is consistent with other SVR research, which has found that language comprehension ability becomes a better predictor of reading comprehension ability than decoding ability in the later primary years (Catts et al., 2006; Chen & Vellutino, 1997; Gustafson et al., 2013; Hoover & Gough, 1990).

The third study, conducted by Ebert and Scott (2016), included 112 children who had been referred for a speech language assessment. These children ranged in age from 6.0 to 16.7 years. Ebert and Scott included all participants who had been referred for a speech language assessment. This approach was similar to that used by Catts and colleagues (2003). However, unlike Catts and colleagues, Ebert and Scott did not screen out children who were not poor readers. This meant that while all of the children in this study had been referred for a speech language assessment, they were not all poor readers.

The children completed decoding, listening comprehension, oral expression, and reading comprehension assessments. Ebert and Scott (2016) classified participants using two different approaches. In the first approach, the participants were classified according to their performance on decoding and listening comprehension (language comprehension variable) variables. In the second approach, the participants were classified according to their performance on decoding and oral expression (language comprehension variable) variables. A cut-off point for poor performance in decoding and language comprehension was set at one standard deviation below the mean. Participants were then assigned to the dyslexia, SCD, mixed, or unexplained poor reader category using the same method employed by Catts et al. (2003). Multiple tests contributed to each child’s score on the decoding, listening comprehension, and oral expression variables. For example, the participants’ performance on word attack, word identification, spelling, and reading rate tests contributed to their decoding score. Tests that assessed a child’s ability to follow oral instructions, identify synonyms, answer questions about an orally presented passage, and match orally presented words and sentences to pictures contributed to their listening comprehension score. Tests that assessed children’s ability to repeat a sentence, construct a sentence with a target word, and tell a story contributed to their oral expression score.

Ebert and Scott (2016) found that a similar proportion of children were assigned to each poor reader category in both classification approaches. The following figures report the proportion of children who fell in each poor reader category using the first classification approach. The percentage in brackets represents the proportion of children who were classified using the second approach. Ebert and Scott found that 6.9% (4.4%) of children fell in the dyslexia group, 31.9% (36.7%) of children fell in the SCD group, 20.8% (25%) of children fell in the mixed difficulty group, and 40.4% (33.9%) of children fell in the unexplained difficulty group. These proportions must be viewed cautiously because Ebert and Scott's selection criteria meant that children who did not exhibit reading difficulties were included within these figures. In addition to these figures, Ebert and Scott reported the percentage of children in each poor reader group who were also poor readers. Between 60% and 70% of children assigned to the dyslexia and SCD groups and between 75% and 80% of children in the mixed difficulty group performed one standard deviation below the mean on the reading comprehension variable. This means that some of the poor reader groups included a very small number of poor readers. While a similar proportion of participants fell in each poor reader category using either classification approach, it is not possible to ascertain whether it was the same participants who fell in each poor reader category in these analyses. If the language comprehension variable can be assessed using tests that assess either oral expression or listening comprehension, the groups should remain relatively stable across both classification approaches.

The most recent classification study (Morris et al., 2017) included 65 participants from Grades 5 and 6 who performed below the 50th percentile on an end-of-grade reading comprehension test. These participants completed word recognition, reading rate, reading accuracy, reading comprehension, and picture vocabulary assessments. Participants were classified according to their decoding (reading accuracy and reading rate) and language comprehension (picture vocabulary) ability. If their reading accuracy was less than 94% and their reading rate was less than 105 words per minute, they were deemed to have difficulties with decoding. If they scored below the 40th percentile on the picture vocabulary test, they were deemed to have language comprehension difficulties. Using these cut-off points, children were assigned to one of the four poor reader categories. Morris and colleagues found that 48% of the participants fell within the mixed difficulty group, 14% fell within the dyslexia group, 25% fell within the SCD group, and 14% fell within the unexplained reading difficulty group.

These results should be interpreted cautiously for two reasons. First, this study included a relatively small number of children. As a result, only a small number of children were assigned to some of the poor reader categories. For example, only nine children were assigned to the dyslexia group. The second limitation concerns the way the language comprehension variable was operationally defined. The authors assessed language comprehension using a vocabulary assessment. Assessing only vocabulary ability provides a narrow assessment of a child's language comprehension ability. The other classification studies included a broader assessment of language comprehension ability, which is more consistent with the way language comprehension is defined within the SVR: extracting and constructing literal and inferred meanings from linguistic discourse (Hoover & Tunmer, 2018).

2.9 Poor Reader Profiles

Research has frequently identified two distinct poor reader profiles. The first group demonstrate difficulty decoding words, and the second group demonstrate difficulty understanding spoken language (Aaron et al., 1999; Catts et al., 2003; Ebert & Scott, 2016; Morris et al., 2017). Poor readers who exhibit language comprehension difficulties share many similarities with children who exhibit a specific language impairment (SLI; Kelso et al., 2007). SLI is the most frequently studied developmental language disorder (Catts, Hogan, et al., 2005). Terms such as developmental language disorder, language impairment, language disability, language learning disability, and oral and written language impairment have also been used to refer to this group (Lauterbach et al., 2017). Some researchers have argued that children with an auditory processing disorder should be included within this group because they exhibit a similar profile to children with an SLI on cognitive assessments (Ferguson et al., 2011; Miller & Wagstaff, 2011). The most frequently studied developmental reading disorder is dyslexia (Catts, Hogan, et al., 2005). Children with dyslexia exhibit decoding difficulties in the absence of language comprehension difficulties (Aaron et al., 1999; Catts et al., 2003; Ebert & Scott, 2016; Gough & Tunmer, 1986; Morris et al., 2017).

Dyslexia is defined as a neurological learning difficulty (International Dyslexia Association, 2002; Ministry of Education, 2020), which is characterised by difficulty decoding words (American Psychiatric Association, 2013; Gough & Tunmer, 1986; International Dyslexia Association, 2002; Ministry of Education, 2020; Rose, 2009) because of impaired phonological processing skills (International Dyslexia Association, 2002; Ministry of Education, 2020; Rose, 2009). These difficulties are evident despite adequate instruction (American Psychiatric Association, 2013; International Dyslexia Association, 2002; Ministry of Education, 2020), persistent over time (American Psychiatric Association, 2013; Ministry of Education, 2020), and unexpected in relation to a child’s oral language ability (Gough & Tunmer, 1986; International Dyslexia Association, 2002; Ministry of Education, 2020). Children with SLI exhibit difficulties across a range of skills associated with language comprehension (Cain & Oakhill, 2006, 2007; Lauterbach et al., 2017) that are not better explained by other physical or neurological impairments (Bishop & Snowling, 2004; Cain & Oakhill, 2007). Like children with dyslexia, these children exhibit phonological awareness difficulties (Bishop & Snowling, 2004; Lauterbach et al., 2017) and their difficulties are persistent over time (Cain & Oakhill, 2006). Research has attempted to identify the cognitive factors that can be used to discriminate between children who exhibit the SLI profile and those who exhibit the dyslexia profile. Some studies have found that children with language comprehension difficulties also demonstrate impairment on tests that assess syntax knowledge, auditory perception, verbal working memory, and speed of processing (Leonard, 2014). However, many of these difficulties have also been observed in children with dyslexia (Bishop & Snowling, 2004; Diamanti et al., 2018; Lauterbach et al., 2017).

A number of studies have investigated whether dyslexia and SLI are two distinct disorders or different forms of the same developmental language disorder (Bishop & Snowling, 2004; Catts et al., 2006; Lauterbach et al., 2017). The relationship between dyslexia and SLI could be explained through one of three models (Catts, Adlof, et al., 2005; Lauterbach et al., 2017). In the first model, referred to as a severity model, dyslexia and SLI are hypothesised to be manifestations of the same developmental disorder. Impaired phonological awareness is believed to be the root cause of the difficulties exhibited by both groups. The model predicts that the difference between groups is due to the severity of the phonological difficulties. Children with SLI are predicted to exhibit greater phonological difficulties that result in oral language difficulties in addition to decoding difficulties. The second model, referred to as the additional deficit model, posits that children in the SLI and dyslexia groups have phonological difficulties. However, children in the SLI group are predicted to have an additional cognitive difficulty. This additional cognitive difficulty is believed to be the root cause of differences between these groups. Research has not found support for either of these models. Studies investigating the differences between these groups have found that the SLI group actually outperform the dyslexia group on measures of phonological awareness (Adlof et al., 2006; Catts, Hogan, et al., 2005; Kelso et al., 2007). This finding suggests that neither the severity model nor the additional deficit model accurately reflect the differences between these groups.

The final model is a component model that hypothesises that dyslexia and SLI are distinct disorders with different symptoms due to different underlying cognitive difficulties. Phonological difficulties are believed to be the root cause of decoding difficulties exhibited by children in the dyslexia group and a different lower-level cognitive difficulty is believed to explain the language difficulties exhibited by children with SLI. This model predicts that a third group of children should exhibit difficulties with both of these skills resulting in decoding and language comprehension difficulties. There are parallels between this model and the SVR (Gough & Tunmer, 1986).

Both the SVR and the component model hypothesise the existence of three groups. The dyslexia group is predicted to exhibit decoding difficulties. The SCD group is predicted to exhibit difficulties similar to those demonstrated by children with SLI. However, the SCD group exhibit reading comprehension difficulties in addition to language comprehension difficulties. Deficient language comprehension ability is believed to be the root cause of reading comprehension difficulties exhibited by this group (Aaron et al., 1999; Catts et al., 2003; Ebert & Scott, 2016; Gough & Tunmer, 1986; Morris et al., 2017). They are a subset of all children with SLI (Kelso et al., 2007). Finally, like the component model, the SVR forecasts the existence of a group of children who display difficulties with both decoding and language comprehension. The label mixed difficulty is applied to children who exhibit this poor reader profile.

While the four classification studies described in the previous section all identified the three poor reader groups, only one study (Catts et al., 2003) compared the poor reader groups across a range of cognitive processes. Many of these comparisons were conducted when the children were in kindergarten and second grade. A small number of additional comparisons were made when the children were in fourth grade. In second grade, the grade in which children were classified, children in the dyslexia group demonstrated greater difficulties than children in the SCD group on a measure of decoding ability, and children in the SCD group demonstrated greater difficulties than children in the dyslexia group on a language comprehension variable. These groups did not differ in their reading comprehension ability, phonological awareness, or rapid naming ability. This finding may be due to the way these variables were operationalised and the age of the participants.

The term phonological difficulties can be used to refer to a wide range of skills involving speech sounds (Bishop & Snowling, 2004). The phonological processing measure administered by Catts and colleagues (2003) assessed children's ability to delete a syllable or sound and verbalise the remaining sound sequence. It is possible that assessing this construct more broadly may identify phonological processes that can be used to discriminate between these two poor reader groups. Phonological processing ability generally improves with age and instruction (Mahfoudhi & Haynes, 2009; Snowling et al., 2019; Vellutino et al., 1996) so phonological processing measures that differentiate between poor reader groups may differ across grade levels. Lauterbach et al. (2017) found that it was possible to differentiate between participants (aged 7–20 years old) with dyslexia and SLI using a discriminant function analysis that included language comprehension, word attack, and phonological awareness measures. The phonological awareness measure assessed the participants' ability to delete a sound within a word to create a new word. This is a relatively complex phonological awareness skill. The results from this study suggest that it may be possible to differentiate between children with dyslexia and those with SCD using similar assessments.

The way Catts et al. (2003) operationalised the rapid naming variable and the age of the participants in this study may explain why children in the dyslexia and SCD groups did not differ on this variable. Catts et al. (2003) assessed the children's rapid naming ability in second grade using a picture naming test. Research suggests that alphanumeric naming speed is more closely associated with decoding ability than non-alphanumeric naming speed (Araújo & Faísca, 2019; Georgiou et al., 2009; Vellutino et al., 2004), and the rapid naming difficulties exhibited by children with dyslexia are believed to become more pronounced over time (Araújo & Faísca, 2019). Catts and colleagues may have obtained different results if they had included older children in their research and operationalised the rapid naming measure with a rapid letter naming task.

2.10 Gaps in the Literature

The introduction section identified three gaps in the literature. These gaps relate to limitations associated with the SVR studies described in the previous sections. This section elaborates on these three gaps in the literature. The first gap relates to methodological limitations in previous SVR research, which have meant that previous studies have not established that the SVR can be used as a valid classification system. Specifically, limitations related to the sample size and participant recruitment criteria as well as analysis and interpretation limitations mean that further investigation is required. As a result of these limitations, it is possible that previous classification studies either over- or underestimated the proportion of children classified as having dyslexia, SCD, or a mixed difficulty. In addition, previous studies have not been able to rule out the possibility that there is a group of children whose reading difficulties cannot be explained by the SVR.

One of the greatest challenges faced by researchers who wish to conduct classification research is identifying a sufficiently large sample of poor readers. If a sufficiently large sample cannot be obtained, a limited number of children are assigned to some of the smaller poor reader categories. This makes it difficult to determine whether the proportion of children assigned to each poor reader category are likely to be representative of all poor readers. In many cases, a large number of children must be screened to identify a sufficient number of struggling readers. For example, Aaron et al. (1999) screened 139 children to find 16 poor readers. The three other classification studies took steps to overcome this challenge (Catts et al., 2003; Ebert & Scott, 2016; Morris et al., 2017). Ebert and Scott (2016) selected participants who had been referred for speech language assessments, and Catts and colleagues (2003) selected participants who were taking part in a longitudinal study on language impairments. This decision increased the likelihood that these studies would find a sufficiently large sample of poor readers because children with language difficulties are more likely than typically achieving children to exhibit reading difficulties (Cain & Oakhill, 2007; Catts et al., 2003). However, there are risks associated with this approach. It is possible that the poor readers who took part in the studies conducted by Ebert and Scott (2016) and Catts et al. (2003) are not representative of all poor readers because these children had speech and language difficulties. This means the results obtained in these studies should be interpreted cautiously.

Ebert and Scott (2016) took an additional step to increase the number of participants they included in their research. They accepted participants from a far wider age range than any of the other studies (6–16.7 years of age). The contribution that language comprehension makes to reading comprehension relative to decoding ability increases over time (Adlof et al., 2006; Catts, 2018; Georgiou et al., 2009). Research by Catts and colleagues (2005) has shown that this change influences the proportion of children who are assigned to each poor reader category. Compared with studies with younger participants, studies that classify older children are likely to identify a larger proportion of children who exhibit the SCD profile and a smaller proportion of children who exhibit the dyslexia profile. Because of this effect, the results from Ebert and Scott's study should be interpreted cautiously. This limitation can be mitigated by including participants who are similar in age or by reporting results for separate age groups when working with participants that span a wide age range.

Morris et al. (2017) adopted an alternative approach. They identified poor readers using more liberal participant selection criteria than the aforementioned classification studies. Rather than identifying children performing below the 16th percentile, like many of the other studies (Aaron et al., 1999; Catts et al., 2003; Ebert & Scott, 2016), they accepted children who were performing below the 50th percentile on an end-of-year reading test. This means that at least some of the children included in their study were typically achieving readers. Catts et al. (2003) hypothesised that including typically achieving children within a classification study could be one of the reasons why an unexplained group of poor readers is identified. When typically achieving children are included within classification studies, they are likely to fall within the unexplained poor reader group because it is unlikely they will exhibit pronounced decoding and/or language comprehension difficulties.

Previous classification studies have used cut-off points on the decoding and language comprehension variables to distinguish between typically achieving children and children who struggle with these skills. Catts et al. (2003) conjectured that the use of cut-off points could explain why a group of unexplained poor readers has been identified in previous classification studies. Decoding and language comprehension ability fall on a continuum, which means there is no obvious cut-off point that can be used to distinguish between poor and typically developing readers. When children are separated using cut-off points, research has identified the three poor reader groups predicted by the SVR and a group of unexplained poor readers. However, if higher cut-off points were used, no children would fall within the unexplained poor reader category.

The placement of cut-off points also influences the proportion of poor readers that are assigned to each poor reader category. Fewer children would be assigned to the dyslexia and SCD groups if the cut-off points were raised from their traditional placement. Children in the SCD group who performed just above the decoding cut-off point and children in the dyslexia group who performed just above the language comprehension cut-off point would be assigned to the mixed difficulty group if cut-off points were raised. Conversely, a greater proportion of struggling readers would be assigned to the dyslexia and SCD groups if the cut-off points were lowered.

Previous classification studies have not examined the cognitive profiles of the poor reader groups in sufficient detail. This is the second limitation associated with previous classification studies. Catts et al. (2003) were the only researchers to compare the poor reader groups across a number of cognitive processes. Analyses compared the groups on measures of decoding, language comprehension, reading comprehension, phonological awareness, rapid naming ability, and a measure that assessed their reading experience (title recognition test). Many of the results reported in this research fell in the expected direction. For example, the dyslexia group performed more poorly than the SCD group on the decoding assessment and the SCD group performed more poorly than the dyslexia group on the language comprehension assessment. As expected, the mixed difficulty group exhibited difficulties on both of these skills. The results on the phonological awareness and rapid naming assessments were not consistent with expectations. Children with dyslexia are expected to demonstrate greater difficulties with these skills than children who exhibit the SCD profile (Catts et al., 2003; Lauterbach et al., 2017). However, Catts and colleagues found no significant difference between the dyslexia and SCD groups on these assessments. The results reported in this study may be influenced by the way the authors chose to operationalise rapid naming and phonological awareness. Rapid naming ability was operationalised with a picture naming test.

However, research indicates that alphanumeric naming tests are more closely associated with reading than picture naming tests (Araújo et al., 2015; Georgiou & Das, 2018). Catts and colleagues assessed one type of phonological awareness ability. However, a number of skills are incorporated within this umbrella term. It is possible that the relative strengths and weaknesses experienced by these groups may differ across a broader range of phonological awareness skills.

To develop instructional programmes based on the SVR, teachers must be able to ascertain their children's decoding and language comprehension proficiency. However, previous classification studies have not investigated whether assessments available to teachers can be used for classification purposes. This is the third gap in the literature. Many of the measures that are traditionally used in classification studies cannot be accessed by teachers. For example, the Woodcock-Johnson IV (WJIV; Schrank et al., 2014) can only be purchased by individuals with New Zealand Council for Educational Research (NZCER) Registration Level C. To gain this registration level, an individual must have completed an advanced course in psychometric testing as well as an advanced course in personality/abnormal theory (NZCER, n.d.-a). These courses are not included within teacher training programmes, which means it is unlikely teachers will meet the criteria to access and administer these tests.

2.11 Purpose and Research Questions

This research aimed to addresses many of the limitations associated with the previous classification studies. It included a relatively large sample of children, of a similar age, who were not initially identified because of some other learning difficulty. This step increased the likelihood that the results obtained with this sample of poor readers will be representative of all poor readers. The use of cut-off points to classify poor readers may have influenced the results obtained in previous classification studies. This research classified children using the traditional classification approach and other approaches based on significant differences and cluster analyses. Previous research has not adequately investigated whether the poor reader groups demonstrate distinct cognitive profiles. By including a large number of children, the poor reader groups could be compared across a range of cognitive processes associated with reading. Administering all the tests within a short period ensured the results that children obtained reflected their current ability on these tests. It also means that the skills were operationalised using developmentally appropriate assessments. Finally, this study investigated whether tests with teacher-level restrictions can be used to classify poor readers. In summary, this research investigated three research questions: (1) Is there a better way to classify poor readers using the SVR than the traditional classification approach? (2) Do the poor reader groups exhibit distinct cognitive profiles? (3) Can tests with teacher-level restrictions be used to classify poor readers?

Chapter 3 Method

This chapter describes the participants and the participant selection criteria. It then outlines the assessment procedures that were followed and describes the 14 tests that were administered in this research.

3.1 Participants

This research included children from nine primary schools located in one city within the South Island of Aotearoa New Zealand. These children were in Year 4, 5, or 6 (aged 8–10 years, Grades 3–5). Children in these school year groups were targeted given that reading comprehension ability has been found to be influenced, to a similar extent, by both decoding and language comprehension ability in this age range (Adlof et al., 2006; Catts, 2018; Georgiou et al., 2009). The schools were asked to identify children who performed below the 40th percentile on one of two school-based standardised assessments that are commonly used within Aotearoa New Zealand: the e-asTTle Reading test (Auckland UniServices Limited, 2009) or the Progressive Achievement Test for Reading Comprehension (Darr et al., 2008). Teachers were also allowed to nominate children who exhibited reading difficulties on other school assessments. All of the children identified by schools were invited to take part in this research.

In total, 216 English-speaking children took part in this study. Seven children performed above the 40th percentile on the researcher-administered Passage Comprehension test from the WJIV and were excluded from the research, leaving a final sample of 209 children. The majority of the children in this study (73%) came from schools in higher socio-economic communities, and the average age of the participants was nine years and eight months (SD_{age} = 11 months). Table 3.1 provides an overview of the participants broken down by grade and gender. This research adhered to the ethical requirements of the participating university.

Table 3.1

Participant Demographics

Year	Males *n*(% of gender)	Females *n*(% of gender)	Total *n*(% of all participants)
4	35 (62.5%)	21 (37.5%)	56 (26.8%)
5	49 (68.1%)	23 (31.9%)	72 (34.4%)
6	46 (56.8%)	35 (43.2%)	81 (38.8%)
Total	130 (62.2%)	79 (37.8%)	209 (100.0%)

3.2 Procedure and Measures

All children from Years 4, 5, and 6 undertook the same 14 individually administered assessments across four separate sessions. Each assessment session lasted approximately 20 minutes, and every child completed the assessments within a two-week period. The assessments were administered in a quiet room provided by each school, and all tests were administered by the researcher following the procedures outlined in the testing manuals. The data were collected between March 2019 and March 2020. A second marker reviewed 20% of the assessment record sheets. The second marker checked that the totals for each test had been calculated correctly and that final scores had been entered correctly into the analysis software. No discrepancies between markers were identified during this process.

The following paragraphs describe the tests that were administered in this research. A brief description of each test is provided, and where appropriate, reliability figures are reported. The analysis chapter of this thesis describes how the Word Attack and Letter-Word Identification tests were combined to create a decoding variable and how the Oral Comprehension and Oral Vocabulary tests were combined to create a language comprehension variable. These variables were used in subsequent classification analyses. Catts et al. (2003) hypothesised that the identification of an unexplained group of poor readers could be due to measurement error. To ensure the four aforementioned tests provided a reliable indication of children's decoding and language comprehension ability, reliability scores were calculated. These figures are reported within the relevant sections below.

3.2.1 Reading Comprehension

Reading comprehension ability was assessed using the Passage Comprehension test from the WJIV (Schrank et al., 2014). This test required students to read short passages of text silently and then supply a key missing word in each passage. The initial items on this test were one sentence in length. As children progressed through the test, the items increased in length and complexity. The *Examiners Manual* (Mather & Wendling, 2014) reports median reliability of .89 for the Passage Comprehension test within the 5–19 age range. The Passage Comprehension test from the Woodcock-Johnson III, an earlier edition of the WJIV, has been used in a number of studies investigating reading comprehension proficiency within the SVR model (Braze et al., 2016; Georgiou et al., 2009; Johnston & Kirby, 2006).

3.2.2 Decoding

The Letter-Word Identification, Word Attack, and Word Reading Fluency tests from the WJIV (Schrank et al., 2014) and the Burt Word Recognition Test (Burt test; Gilmore et al., 1981) were used to assess children's decoding ability. The Letter-Word Identification test assessed children's ability to identify and pronounce individual letters and words, and the Word Attack test assessed children's ability to pronounce non-words that conform to English spelling rules. A number of SVR studies have used versions of the Word Attack (Adlof et al., 2006; Braze et al., 2016; Catts et al., 2006; Georgiou et al., 2009; Harlaar et al., 2010; Johnston & Kirby, 2006; Language and Reading Research Consortium, 2015; Silverman et al., 2013; Tilstra et al., 2009; Tiu et al., 2003; Vellutino et al., 2007) and the Letter-Word Identification (Adlof et al., 2006; Catts et al., 2006; Harlaar et al., 2010; Language and

Reading Research Consortium, 2015; Tiu et al., 2003; Vellutino et al., 2007) tests to assess decoding ability. The Letter-Word Identification (*r* = .95) and Word Attack (*r* = .87) tests demonstrated excellent reliability within this sample. These figures were similar to those reported in the WJIV manual (Schrank et al., 2014; Letter-Word Identification = .92, Word Attack = .90).

Assessing both word attack and word identification ability is known to provide a more complete picture of children's decoding ability than relying on a test that assesses only one of these skills (Gustafson et al., 2013; Hoover & Gough, 1990; Language and Reading Research Consortium, 2015; Vellutino et al., 2007). Both tests were administered following the procedures described in the WJIV manual and were stopped when a child made six consecutive errors. The Letter-Word Identification and Word Attack tests contributed to a composite decoding score that was calculated for each child. The analysis section describes how the composite score was calculated.

The Burt test assessed children's ability to read a range of regular and irregular words that increased in length and complexity. Test administration was terminated when children were unable to correctly read 10 consecutive items. The test manual reports high internal consistency (.97) within the 8.03–10.09 age range (Gilmore et al., 1981). Unlike tests from the WJIV, this test can be accessed by teachers without any additional instruction or registration requirements and is commonly used in New Zealand.

Reading fluency was assessed using the Word Reading Fluency test from the WJIV. This test assessed children's ability to quickly read rows of words and circle the two words that go together. Children were told they had three minutes to complete as many questions as possible. Each correctly answered question received one mark. The administration manual reports a median reliability of .92 in the 7–11 age range (Schrank et al., 2014).

3.2.3 Language Comprehension

Ensuring that reading comprehension and language comprehension tests are well matched is a prerequisite for SVR research (Tunmer & Hoover, 2019). This requirement was met by administering the Oral Comprehension test from the WJIV. This test is similar to the Passage Comprehension test. It required children to provide the missing word in short passages that increased in length and complexity as they progressed through the test. The key difference between the Oral Comprehension test and the Passage Comprehension test is the method of presentation. Items on the Oral Comprehension test are presented orally and items on the Passage Comprehension test are presented as text.

Language comprehension is often operationalised by asking children to orally answer questions about orally presented passages (Kershaw & Schatschneider, 2012). However, some researchers have suggested that this is an inadequate approach (Savage et al., 2015; Silverman et al., 2013; Tunmer & Chapman, 2012). Assessing vocabulary knowledge in addition to listening comprehension ability is believed to provide a better indication of children's language comprehension ability (Braze et al., 2007; Silverman et al., 2013). Of the four previous classification studies, two used a combination of oral comprehension and vocabulary measures to assess language comprehension ability (Aaron et al., 1999; Catts et al., 2003). This research adopted a similar approach by administering tests that assessed vocabulary ability in addition to the Oral Comprehension test. Vocabulary knowledge was assessed using the Oral Vocabulary test from the WJIV. This test required children to provide synonyms and antonyms for orally presented words. The Oral Vocabulary and the Oral Comprehension tests contributed to a composite language comprehension score. The analysis chapter describes how this score was calculated.

To ensure the Oral Comprehension and Oral Vocabulary tests provided a reliable indication of children's language comprehension ability, reliability coefficients were calculated. The tests demonstrated excellent reliability within this sample (Oral Comprehension = .75; Oral Vocabulary = .84). These figures are similar to those reported in the WJIV manual (Schrank et al., 2014; Oral Comprehension = .82, Oral Vocabulary = .89). The tests were administered following the procedures outlined in the WJIV manual. In accordance with these procedures, test administration was stopped when a child made six consecutive errors.

Children also completed the British Picture Vocabulary Scale, 3rd Edition (BPVS-III; Dunn et al., 2009). This test assessed children’s receptive vocabulary. Children were required to identify one picture from a selection of four pictures that represented an orally presented word. A reliability figure of .91 has been reported for this measure (Dockrell et al., 2010). This test was discontinued once children made eight or more errors in a set of 12 items.

3.2.4 Rapid Naming

Children’s rapid automatic naming speed was assessed using the Rapid Digit Naming and Rapid Letter Naming tests from the Comprehensive Test of Phonological Processing (CTOPP-2; Wagner et al., 2013). These tests assessed how quickly children could name an array of digits or letters. The *Examiners Manual* reported excellent test-retest reliabilities for these tests within the 7–11 age range (Rapid Digit Naming test = .90; Rapid Letter Naming test = .93).

3.2.5 Phonological Awareness

The phonological awareness construct was assessed using the Phonological Processing test from the WJIV and the Blending Words, Phoneme Isolation, and Elision tests from the CTOPP-2. The Phonological Processing test is composed of three subtests. The first subtest assessed children’s ability to name words with certain sounds in a specific location within the word. For example, one of the first items in this test asked children to name a word that begins with the *t* sound. Later items asked children to name words with a specific sound in the middle or end of words. The second subtest assessed children's ability to rapidly name words that start with a certain sound. Children had two attempts to name as many words as possible within one minute. The initial sound varied across the two presentations. The final subtest required children to substitute a sound in a word for another sound, to create a new word. For example, one of the items at the beginning of this test asked children to change the *t* sound in *tag* to *b*. The test has a median reliability of .83 in the 5–19 age range (Schrank et al., 2014). Children proceeded through subtest one and three until they made six consecutive errors.

The Blending Words test, from the CTOPP-2, assessed children's ability to combine sounds to form words. These items increased in length and complexity as the test progressed. The Phoneme Isolation test assessed children's ability to identify specific sounds within words. For example, children were asked to identify the last sound in *laugh*. The Elision test assessed children's ability to delete a sound within a word to create a new word: say *cup* without saying *k*. The *Examiners Manual* reports reliability coefficients greater than .93 on the CTOPP-2 tests (Wagner et al., 2013). These tests were discontinued when a child obtained three consecutive errors.

For ease of reference, Table 3.2 lists every test that was administered in this research. It notes which construct each of the 14 tests assessed and reports the registration level that is associated with these tests. The registration levels range from C to A. Test administrators with a Level C registration must have completed an advanced course in psychometric assessment as well as an advanced course in personality/abnormal theory. Test administrators with a Level B registration need only demonstrate a basic understanding of psychometric theory and have specialised knowledge in their area of practice (NZCER, n.d.-a). This means that these tests can be purchased in Aotearoa New Zealand by specialist/resource teachers (B. Stringer, personal communication, August 15, 2018).

Table 3.2

Assessments

Test	Construct	Registration level
WJIV: Passage Comprehension	Reading Comprehension	C
WJIV: Word Attack	Decoding	C
WJIV: Letter-Word Identification		C
BURT Word Recognition		None
WJIV: Word Reading Fluency		C
WJIV: Oral Comprehension	Language Comprehension	C
WJIV: Oral Vocabulary		C
BPVS-III		B
CTOPP-2: Rapid Digit Naming	Rapid Automatic Naming	B
CTOPP-2: Rapid Letter Naming		
WJIV: Phonological Processing	Phonological Awareness	C
CTOPP-2: Elision	Phonological Awareness	B
CTOPP-2: Blending Word	Phonological Awareness	B
CTOPP-2: Phoneme Isolation	Phonological Awareness	B

Note. WJIV = Woodcock-Johnson IV; CTOPP-2 = Comprehensive Test of Phonological Processing; BPVS-III = British Picture Vocabulary Scale, 3rd Edition

Chapter 4 Analyses

This section describes the analyses that were undertaken in this research. The analyses have been organised according to the research question that they address. Analyses related to the first question compared the traditional classification approach with alternative classification approaches, all based on predictions derived from the SVR. The second question examined more closely the classification approach that provided the best explanation for children's reading difficulties. The analyses associated with this question investigated whether the poor reader groups demonstrated distinct cognitive profiles. The final question explored whether tests with teacher-level restrictions can be used to classify poor readers. The analyses associated with this question compared a classification approach based on teacher-level tests with the approach that provided the best explanation for children's reading difficulties in the analyses conducted for the first research question. Additional information related to specific analyses are reported within the corresponding sections of the results. All the analyses described in this chapter were performed using IBM SPSS Statistics for Windows, version 26.0.

4.1 Analyses Related to Research Question 1

The analyses undertaken in this section compared and evaluated a number of classification approaches based on the SVR. These approaches can be grouped into those based on the traditional classification approach, two-step cluster analyses, and significant differences. First, a composite decoding and language comprehension score was calculated for each child. The decoding score was obtained by finding the average of each child's score on the Word Attack and Letter-Word Identification tests. The language comprehension score was found by averaging each child's score on the Oral Comprehension and Oral Vocabulary tests. From this point forward, these composite scores are referred to as decoding and language comprehension scores. Weighted decoding and language comprehension scores were also calculated. These weighted scores were based on principal component analyses. The Word Attack, Letter-Word Identification, Word Reading Fluency, and Burt tests contributed to the decoding factor, and the Oral Comprehension, Oral Vocabulary, and BPVS-III tests contributed to the language comprehension factor. From this point forward, these scores are referred to as weighted decoding and weighted language comprehension scores. Unless otherwise stated, the following classification approaches were based on the decoding and language comprehension scores.

Initially, children were assigned to poor reader groups using the same approach described in previous SVR research (Aaron et al., 1999; Catts et al., 2003). This approach is referred to as the traditional classification approach. Children who obtained a standard score less than 85 (one standard deviation below the mean) on the decoding and language comprehension variable were assigned to the mixed difficulty group. Children who obtained a decoding score of 85 or greater and a language comprehension score less than 85 were assigned to the SCD group, and children who obtained a decoding score less than 85 and a language comprehension score of 85 or greater were assigned to the dyslexia group.

Children were then classified based on their decoding and language comprehension scores using a two-step cluster analysis. Cluster analyses aim to maximise the homogeneity within groups and maximise the heterogeneity between groups. The two-step cluster analysis grouped children using two steps. In the first step, the program examined every record and decided whether that record should be merged with a previously formed group of records (cluster) or whether it should form the basis for a new cluster based on a specified distance criterion. In the second step, the program took the clusters that were identified in the first step and grouped them into the desired number of clusters. The program can determine the optimal number of clusters, or these can be set prior to the analysis. Both of these options have been used in this research. The main analyses used the decoding and language comprehension scores, but an additional two-step cluster analysis was also performed using the weighted decoding and weighted language comprehension variables.

A different set of analyses grouped children using a significant difference approach. Children were assigned to the SCD group if they performed significantly better on the decoding variable than the language comprehension variable, and they were assigned to the dyslexia group if they performed significantly better on the language comprehension variable than the decoding variable. If there was no significant difference between a child's scores on these variables, the child was assigned to the mixed difficulty group. Three different confidence intervals were used to determine significant differences.

For all of the above analyses, children's performance on the decoding and language comprehension variables are displayed on a scatter plot. Children are grouped using the corresponding classification approach, and the proportion of children assigned to each poor reader category is reported.

Multinomial logistic regression analyses were conducted for each classification approach. This type of analysis is used to model the predictive relationship between independent variables and dependent unordered categorical variables. In this research, the poor reader groups were the dependent variable and the independent variables were the tests that were administered. For every analysis, the results section identifies the tests that contributed significantly to a model that predicted group membership. These analyses report the proportion of children that the model was able to accurately classify. The results from these analyses were considered when comparing and evaluating the various classification approaches.

4.2 Analyses Related to Research Question 2

This section compares the dyslexia, SCD, and mixed difficulty groups' performance across the 14 assessments. These comparisons are based on the optimal classification approach that was identified in the analyses associated with Research Question 1. Analysis of variance (ANOVA) was conducted for each of the 14 test comparisons. Post hoc tests are reported where a significant ANOVA result was found. Violations of the assumption of equal variance were also taken into account in these analyses, and varying post hoc analyses were performed where the data warranted. Alpha was set at .05 for all comparisons.

4.3 Analyses Related to Research Question 3

The analyses in this section evaluate whether the Burt and BPVS-III tests can be used for classification purposes. The first analysis investigated the relationship (correlation) between the Burt test and the decoding variable and between the BPVS-III test and the language comprehension variable. The next analysis investigated whether these tests could be used for classification purposes. The Burt test and BPVS-III were entered into a two-step cluster analysis, and a cluster membership variable was created. A scatter plot was created using the same process described previously (see Section 4.1), and children were grouped using the cluster membership variable. The results from these analyses were then compared with those obtained using the optimal classification approach that was identified in Section 5.2 of the results (see Figure 5.2 and Table 5.8 for comparison). These groups were then compared across all 14 assessments using the same process described previously (see Section 4.2).

Chapter 5 Results

This chapter comprises four sections. Section 5.1 provides an overview of the children's performance on each of the assessments. Section 5.2 details the analyses associated with Research Question 1, which compared and evaluated classification approaches based on the SVR. Section 5.3 reports the results associated with Research Question 2. These analyses compared the poor reader groups that were identified in the analyses associated with Research Question 1. Section 5.4 reports the analyses associated with Research Question 3, which compared a classification approach based on teacher-level assessments with the approach that provided the best explanation for children's reading difficulties (see Section 5.2.4).

5.1 Descriptive Statistics

Table 5.1 reports the mean and standard deviation in raw scores for each test that was administered. These scores are reported by year level. The scores for the Rapid Digit Naming and Rapid Letter Naming tests were measured in seconds, with faster response times indicating better performance than slower response times. In total, 209 children completed 13 of the 14 assessments. Three children were unable to complete the practice items on the Word Reading Fluency test. In accordance with the instruction manual, the test items from the Word Reading Fluency test were not administered to these three children. Two of these children were in Year 6 and the third child was in Year 4. These children were still able to complete the 13 other assessments. They were included in all classification analyses and all comparison analyses, aside from analyses that compared students' scores on the Word Reading Fluency test. With the exception of these three children and the Word Reading Fluency test, 81 children from Year 6, 72 children from Year 5, and 56 children from Year 4 completed the assessments.

Table 5.1

Descriptive Statistics

Test	Construct	Year 4 *M* (*SD*)	Year 5 *M* (*SD*)	Year 6 *M* (*SD*)	Total *M* (*SD*)
Passage Comp[a]	Reading comprehension	22.38 (3.70)	23.92 (3.71)	26.94 (4.46)	24.67 (4.42)
Word Attack[a]	Decoding	12.73 (3.70)	15.83 (4.56)	17.17 (4.82)	15.52 (4.78)
Letter-Word Identification[a]	Decoding	40.48 (7.48)	44.76 (8.63)	49.56 (9.09)	45.47 (9.24)
Burt	Decoding	37.71 (11.10)	47.64 (14.47)	57.93 (16.94)	48.97 (16.74)
Word Reading Fluency[a]	Decoding	19.24 (8.18)	25.82 (10.82)	33.80 (8.91)	27.12 (11.08)
Oral Comprehension[a]	Language comprehension	13.59 (3.72)	14.47 (3.11)	16.44 (3.11)	15.00 (3.48)
Oral Vocabulary[a]	Language comprehension	14.77 (4.64)	17.24 (4.44)	19.98 (4.72)	17.64 (5.04)
BPVS-III	Language comprehension	98.59 (16.80)	106.40 (15.36)	115.69 (13.80)	107.91 (16.62)
Phonological Processing[a]	Phonological awareness	27.27 (8.28)	30.14 (8.08)	35.01 (8.37)	31.26 (8.81)
Elision[b]	Phonological awareness	16.59 (4.28)	18.90 (5.48)	21.91 (6.39)	19.45 (5.96)
Blending Words[b]	Phonological awareness	16.75 (5.36)	18.15 (4.09)	19.11 (5.50)	18.15 (5.08)
Phoneme Isolation[b]	Phonological awareness	19.86 (6.43)	18.40 (6.10)	20.78 (6.25)	19.71 (6.30)
Rapid Digit Naming[b]	Rapid naming	22.30 (6.67)	20.22 (5.26)	17.75 (4.76)	19.82 (5.77)
Rapid Letter Naming[b]	Rapid naming	25.29 (6.80)	22.35 (6.51)	19.44 (8.29)	22.01 (7.65)

Note. 206 children completed the Word Reading Fluency test (Year 4 = 55, Year 5 = 72, Year 6 = 79). 209 students completed the remaining tests (Year 4 = 56, Year 5 = 72, Year 6 = 81). Rapid Digit Naming and Rapid Letter Naming scores are measured in seconds. All other test units are number of correct responses (raw scores).

[a]Test from the WJIV

[b]Tests from the CTOPP-2

5.2 Classification Approaches

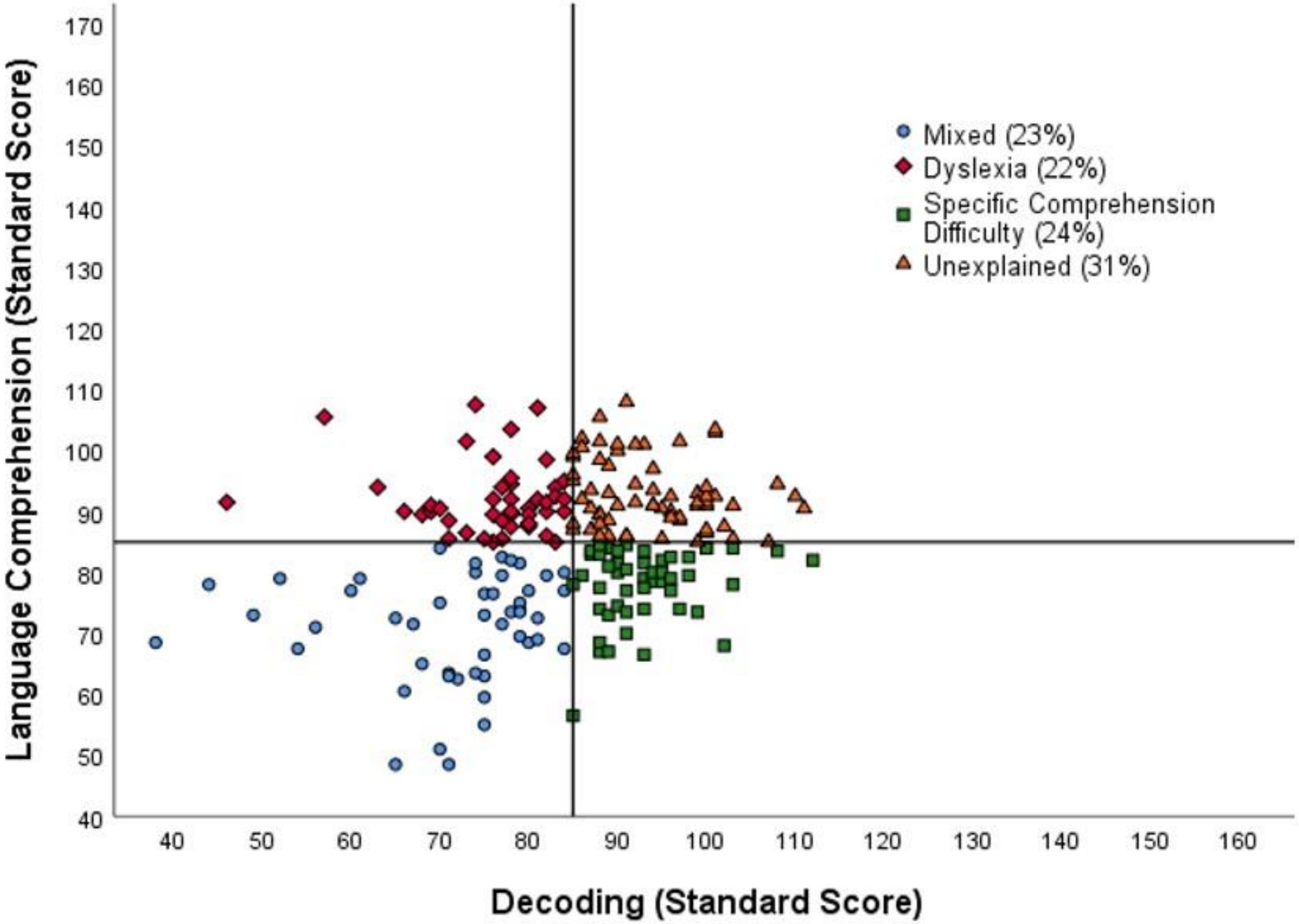
The analyses reported here relate to Research Question 1. This question investigated whether there is a better way to classify poor readers using the SVR than the traditional classification approach. This section reports the proportion of children who were assigned to each poor reader category in the different classification approaches. Multinomial logistic regression analyses are reported for every classification approach. These analyses were used to determine how accurately group membership could be predicted.

5.2.1 Traditional Classification Approach

Children were initially classified using the traditional classification approach. As in previous studies (Aaron et al., 1999; Catts et al., 2003), cut-off lines were placed one standard deviation below the mean (standard score = 85) on the decoding and language comprehension variables. This resulted in 23% of children being assigned to the mixed difficulty group, 22% being assigned to the dyslexia group, 24% being assigned to the SCD group, and 31% being assigned to an unexplained poor reader group (see Figure 5.1).

Figure 5.1

Traditional Classification Approach



A multinomial logistic regression analysis was then conducted. Initially, the Passage Comprehension, Word Reading Fluency, Burt, Rapid Digit Naming, Rapid Letter Naming, Elision, Phonological Processing, Blending Words, Phoneme Isolation, and BPVS-III tests were entered into the analysis. Tests were then removed if they did not contribute significantly to the model. Language comprehension (BPVS-III; $\chi^2 = 45.869$, $p < .001$), decoding (Burt; $\chi^2 = 26.352$, $p < .001$), reading comprehension (Passage Comprehension; $\chi^2 = 30.053$, $p < .001$) and phonological awareness (Elision; $\chi^2 = 30.139$, $p < .001$) tests all contributed significantly to the model. This model was able to accurately predict assignment for 60.0% of all cases in the SCD group, 75.5% of all cases in the mixed difficulty group, 55.6% of all cases in the dyslexia group, and 69.2% of all cases in the unexplained poor reader group. Overall, this model was able to accurately predict group membership for 65.6% of all cases.

Three additional models were estimated. These models compared one poor reader group (SCD, mixed difficulty, or unexplained) with the referent group. In this analysis, and all subsequent multinomial logistic regression analyses, the dyslexia group was used as the referent group. It was chosen because there is a general consensus in the literature about the types of difficulties these children exhibit. For example, children with dyslexia are expected to demonstrate decoding, phonological awareness, and rapid naming difficulties, in the absence of language comprehension difficulties (American Psychiatric Association, 2013; International Dyslexia Association, 2002; Lauterbach et al., 2017; Rose, 2009). Table 5.2 reports the parameter estimates for the analyses. Wald statistics identified which regression coefficients associated with a predictor variable (tests) were significantly different from zero in each of the comparisons. The predictor variables with regression coefficients significantly different from zero are displayed in bold in Table 5.2. The odds ratios (Exp[B]) indicate the risk of an outcome falling in the SCD, mixed difficulty, or unexplained poor reader group relative to the dyslexia group in each model. An odds ratio greater than one signifies that the risk of an outcome falling in a comparison group (the SCD, mixed difficulty, or unexplained poor reader group) relative to the risk of the outcome falling in the dyslexia group increases as the variable increases. The odds ratios reported in Table 5.2 indicate that the risk of an outcome falling in the mixed difficulty group relative to the dyslexia group decreases as scores on the BPVS-III and Passage Comprehension test increase. The risk of an outcome falling in the SCD group rather than the dyslexia group increases as scores on the Elision and Burt tests increase and scores on the BPVS-III decrease. When scores on the Elision and Burt increase, the risk on an outcome falling in the unexplained poor reader group relative to the dyslexia group increases.

Table 5.2

Parameter Estimates for Traditional Classification Approach

Group		*B*	*SE*	Wald	*df*	Sig.	Exp(B)	95% CI for Exp(*B*)	
								Lower limit	Upper limit
Mixed Difficulty	Intercept	16.748	4.881	11.773	1	.001			
	Elision	.051	.041	1.556	1	.212	1.052	.971	1.141
	Burt	.004	.037	.010	1	.921	1.004	.934	1.079
	BPVS-III	**−.141**	**.034**	**17.191**	**1**	**.000**	**.868**	**.812**	**.928**
	Passage Comprehension	**−.133**	**.037**	**12.890**	**1**	**.000**	**.876**	**.814**	**.941**
Specific Comprehension Difficulty	Intercept	−16.856	5.230	10.387	1	.001			
	Elision	**.189**	**.041**	**20.761**	**1**	**.000**	**1.208**	**1.114**	**1.310**
	Burt	**.110**	**.038**	**8.357**	**1**	**.004**	**1.116**	**1.036**	**1.202**
	BPVS-III	**−.119**	**.032**	**13.437**	**1**	**.000**	**.888**	**.833**	**.946**
	Passage Comprehension	.021	.042	.244	1	.622	1.021	.940	1.109
Unexplained	Intercept	−30.175	5.299	32.429	1	.000			
	Elision	**.130**	**.039**	**11.173**	**1**	**.001**	**1.138**	**1.055**	**1.228**
	Burt	**.153**	**.036**	**18.033**	**1**	**.000**	**1.166**	**1.086**	**1.251**
	BPVS-III	.004	.024	.032	1	.858	1.004	.958	1.053
	Passage Comprehension	.079	.041	3.689	1	.055	1.083	.998	1.174

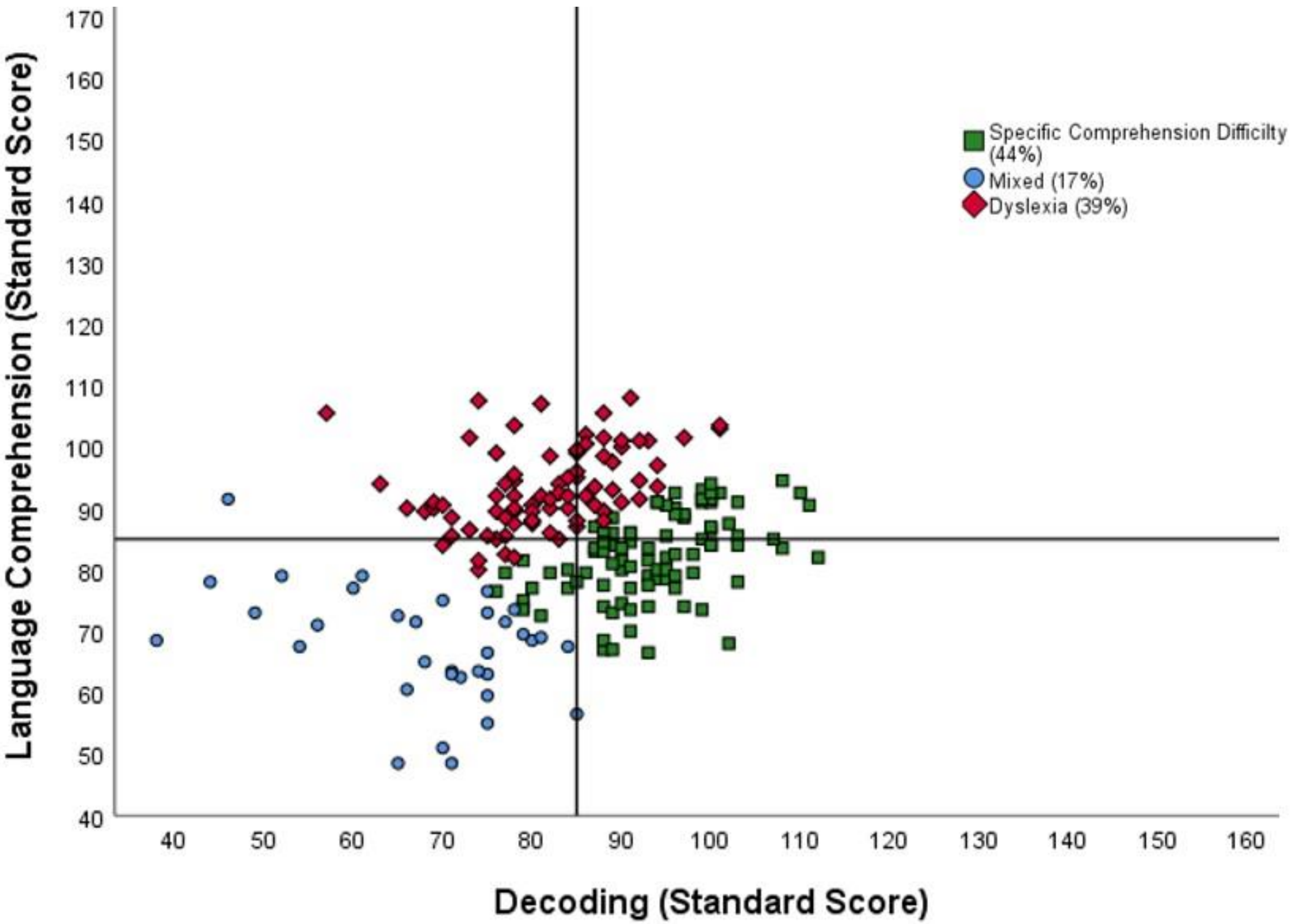
Note. The reference category is Dyslexia.

5.2.2 Cluster Analysis Approach

In this approach, children were classified using a two-step cluster analysis that used log likelihood as the distance measure. All subsequent cluster analyses used the two-step cluster analysis approach. From this point forward, classification based on this approach is referred to as the cluster analysis approach. The analysis software program was allowed to determine the optimal number of groupings. This resulted in three poor reader groups being identified and 17% of children being assigned to the mixed difficulty group, 39% of children assigned to the dyslexia group, and 44% of children assigned to the SCD group. These groupings are displayed in Figure 5.2. This approach did not identify a group of children who exhibited an unexplained poor reader profile.

Figure 5.2

Cluster Analysis Approach



A multinomial logistic regression analysis was again conducted following the same process used with the tradition classification approach. Tests that assessed language comprehension ability (BPVS-III; $\chi^2 = 44.335$, $p < .001$), decoding ability (Burt; $\chi^2 = 18.045$, $p < .001$), reading comprehension (Passage Comprehension test; $\chi^2 = 11.591$, p .003) and phonological awareness (Elision; $\chi^2 = 25.449$, $p < .001$) contributed significantly to the model. The multinomial logistic regression analysis indicated that group membership could be predicted with greater accuracy when children had been grouped using the cluster analysis approach (74.2%) rather than the traditional classification approach (65.6%). The model was able to accurately predict assignment for 78.5% of all cases to the SCD group, 69.1% of all cases to the dyslexia group, and 74.3% of all cases to the mixed difficulty group. This level of accuracy was superior to that obtained when children were grouped using the traditional classification approach (SCD = 60%; dyslexia = 55.6%; mixed difficulty group = 75.5%).

Table 5.3 reports the parameter estimates for models that compared the SCD and mixed difficulty groups with the dyslexia group. Three tests contributed significantly in each model. These tests are shown in bold. In the first model, the odds ratios indicate that the risk of an outcome falling in the SCD group relative to the dyslexia group increases as scores on the Elision and Burt tests increase and scores on the BPVS-III decrease. In the second model, the odds ratios indicate that the risk of an outcome falling in the mixed difficulty group increases as scores on the Burt, BPVS-III and Passage Comprehension tests decrease.

Table 5.3

Parameter Estimates for the Cluster Analysis Approach

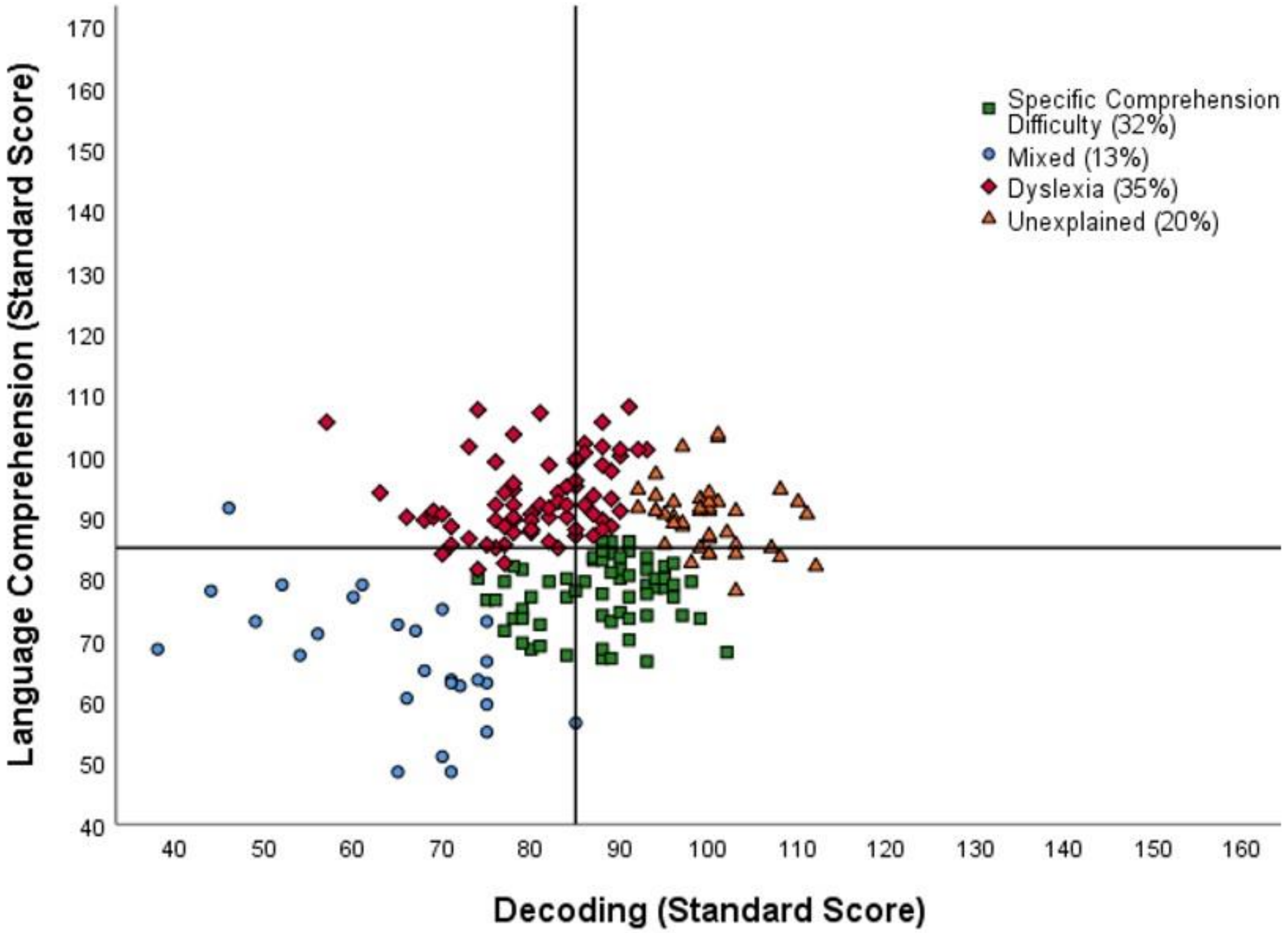
Group		*B*	*SE*	Wald	*df*	Sig.	Exp(B)	95% CI for Exp(*B*)	
								Lower limit	Upper limit
SCD	Intercept	−4.504	2.732	2.719	1	.099			
	Elision	**.107**	**.026**	**17.581**	**1**	**.000**	**1.113**	**1.059**	**1.170**
	Burt	**.069**	**.024**	**8.211**	**1**	**.004**	**1.072**	**1.022**	**1.123**
	BPVS-III	**−.096**	**.023**	**18.080**	**1**	**.000**	**.908**	**.869**	**.949**
	Passage Comprehension	−.031	.029	1.180	1	.277	.969	.916	1.025
Mixed Difficulty	Intercept	33.335	6.966	22.902	1	.000			
	Elision	−.032	.048	.427	1	.513	.969	.881	1.065
	Burt	**−.091**	**.045**	**4.100**	**1**	**.043**	**.913**	**.836**	**.997**
	BPVS-III	**−.198**	**.046**	**18.058**	**1**	**.000**	**.821**	**.749**	**.899**
	Passage Comprehension	**−.123**	**.040**	**9.487**	**1**	**.002**	**.884**	**.817**	**.956**

Note. The reference category is Dyslexia.

A second cluster analysis was conducted to determine whether a four-group model also provided a good fit for the data. In this analysis, the program was forced to identify four groups of poor readers. Using this approach, 13% of poor readers were assigned to the mixed difficulty group, 35% were assigned to the dyslexia group, 32% were assigned to the SCD group, and 20% were assigned to the unexplained poor reader group (see Figure 5.3). A multinomial logistic regression analysis confirmed that group membership could be predicted more accurately using this approach rather than the traditional classification approach. However, this approach was not an improvement on the cluster analysis approach that identified three groups. Overall, 69.4% of cases could be predicted accurately. The analysis indicated that the accuracy with which group membership could be predicted for the mixed difficulty (75.0%) and dyslexia (73.0%) groups was similar to that of the three-group cluster analysis approach. However, assignment to the SCD group was predicted less accurately using this approach (63.6%) rather than the three-group approach (78.5%). The unexplained poor reader group was accurately predicted for 68.3% of all cases. However, this does not mean that an unexplained poor reader group exists. The cluster analysis was forced to identify this group.

Figure 5.3

Four-Group Cluster Analysis Approach



The multinomial logistic regression analysis associated with the three-group cluster analysis approach indicated that children assigned to the unexplained group could be accurately assigned to one of the three poor reader groups predicted by the SVR (dyslexia, mixed difficulty, or SCD). Tests that assessed language comprehension ability (BPVS-III; $\chi^2 = 56.566$, $p < .001$), decoding ability (Burt; $\chi^2 = 49.958$, $p < .001$), reading comprehension (Passage Comprehension test; $\chi^2 = 19.570$, $p = .003$) and phonological awareness (Elision; $\chi^2 = 24.026$, $p < .001$) contributed significantly to the model that predicted the four poor reader groups based on the forced four-group cluster analysis. From this point forward, the term *cluster analysis approach* refers to the approach that identified three poor reader groups. Elsewhere, the term *four-group cluster analysis approach* is used to refer to the classification approach described here, where the analysis software program was forced to identify four poor reader groups.

Table 5.4 reports the parameter estimates for the three models that compared the SCD, mixed difficulty, and unexplained poor reader groups with the dyslexia group. In Model 1, the odds ratios indicate that the risk of an outcome falling in the SCD group, rather than the dyslexia group, increases as scores on the Elision test increase and scores on the BPVS-III decrease. The odds ratios associated with the second model indicate that the risk of an outcome falling in the mixed difficulty group, rather than the dyslexia group, increases as scores on the Burt, BPVS-III, and Passage Comprehension tests decrease. In the final model, the odds ratios indicate that the risk of an outcome falling in the unexplained group, rather than the dyslexia group, increase as scores on the Elision, Burt, and Passage Comprehension tests increase.

Table 5.4

Parameter Estimates for the Four-Group Cluster Analysis Approach

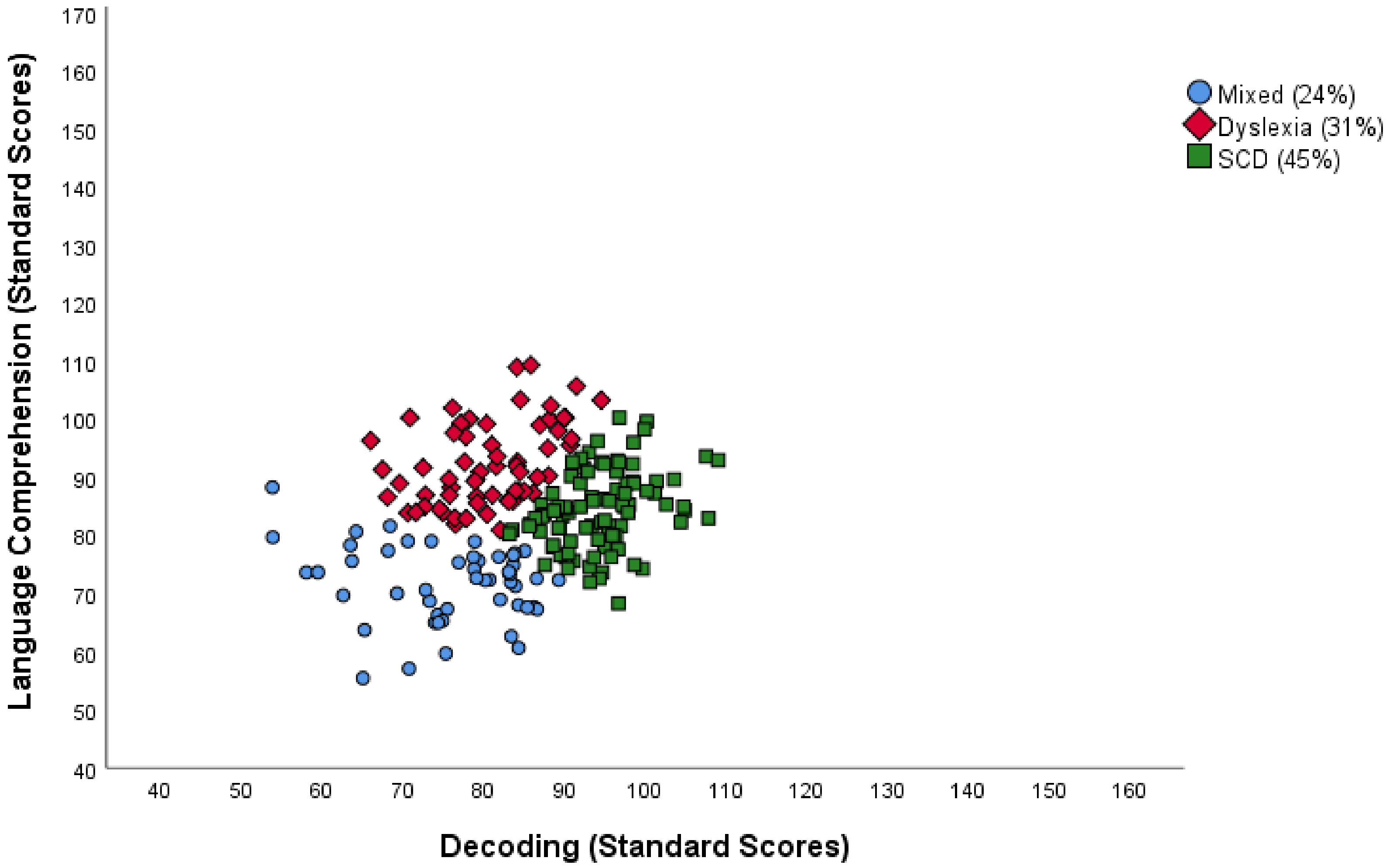
Group		*B*	*SE*	Wald	*df*	Sig.	Exp(*B*)	95% CI for Exp(*B*)	
								Lower limit	Upper limit
SCD	Intercept	2.105	3.401	.383	1	.536			
	Elision	**.111**	**.028**	**15.476**	**1**	**.000**	**1.117**	**1.057**	**1.180**
	Burt	.036	.027	1.757	1	.185	1.037	.983	1.094
	BPVS-III	**−.125**	**.026**	**22.829**	**1**	**.000**	**.883**	**.839**	**.929**
	Passage Comprehension	−.056	.030	3.510	1	.061	.946	.893	1.003
Mixed Difficulty	Intercept	47.627	10.335	21.238	1	.000			
	Elision	.015	.059	.061	1	.804	1.015	.904	1.139
	Burt	**−.247**	**.074**	**11.113**	**1**	**.001**	**.781**	**.675**	**.903**
	BPVS-III	**−.281**	**.068**	**17.082**	**1**	**.000**	**.755**	**.661**	**.863**
	Passage Comprehension	**−.124**	**.047**	**6.957**	**1**	**.008**	**.883**	**.805**	**.969**
Unexplained	Intercept	−33.303	6.297	27.968	1	.000			
	Elision	**.116**	**.032**	**12.896**	**1**	**.000**	**1.123**	**1.054**	**1.196**
	Burt	**.181**	**.042**	**18.586**	**1**	**.000**	**1.198**	**1.104**	**1.301**
	BPVS-III	−.020	.028	.492	1	.483	.980	.927	1.036
	Passage Comprehension	**.097**	**.047**	**4.225**	**1**	**.040**	**1.101**	**1.004**	**1.208**

Note. The reference category is Dyslexia.

A further cluster analysis was undertaken using composite decoding and language comprehension scores based on weights obtained from a principal component analysis. This analysis was undertaken to investigate whether weighted test scores provided a better indication of the children's decoding and language comprehension ability. In the previous analyses, only two tests contributed to the decoding (Word Attack and Letter-Word Identification tests) and language comprehension (Oral Comprehension and Oral Vocabulary tests) variables. The factor scores used in these analyses included a broader range of tests. This meant the breadth of these constructs could be examined in greater detail. The Word Attack, Letter-Word Identification, Word Reading Fluency, and Burt tests contributed to the decoding factor. The Oral Comprehension, Oral Vocabulary, and BPVS-III tests contributed to the language comprehension factor. The factor loadings are shown in Table A1 of Appendix A. A two-step cluster analysis identified the three poor reader groups predicted by the SVR model (dyslexia, SCD, and mixed difficulty). Figure 5.4 displays the proportion of children assigned to each poor reader category. The distribution was similar to that reported in Figure 5.2. Because of the similarity between these approaches, the results associated with this analysis have been reported in Appendix A, rather than within the text. In subsequent sections, only the results associated with the cluster analysis approach based on the composite decoding (Word Attack and Letter-Word Identification tests) and language comprehension variables (Oral Comprehension and Oral Vocabulary tests) are reported in the text.

Figure 5.4

Classification by Cluster Analysis Using Factor Scores



5.2.3 Significant Difference Approach

Children were assigned to one of three poor reader groups using a significant difference approach. A 68% confidence band was identified for each child's decoding and language comprehension scores. If children's bands on the decoding and language comprehension variables did not overlap and their language comprehension standard score was greater than their decoding standard score, they were assigned to the dyslexia group. Alternatively, if their bands did not overlap and their decoding standard score was greater than their language comprehension standard score, they were assigned to the SCD group. If children's bands on the decoding and language comprehension variables overlapped, they were assigned to the mixed difficulty group. A separation between the ends of the decoding and language comprehension bands indicates that there is a significant difference between a child's score on these two variables. A difference of this magnitude would occur by chance less than 16 times in 100 (84% confidence that a true difference exists) if a single comparison was made and if the true scores were actually the same (McGrew, 2016). This confidence interval was used in the first significant difference analysis because it is the approach that is recommended to assessors who use the WJIV (McGrew, 2016). Stricter confidence intervals were also investigated (90% and 95% confidence that a true difference exists). The results from the analyses using the 90% and 95% intervals are reported in Appendix B and Appendix C because they did not provide a better fit for the data than the standard 68%. From this point forward, the term *significant difference approach* refers to classification using the 68% confidence band.

Using the significant difference approach, 33% of children were assigned to the mixed difficulty group, 32% of children were assigned to the dyslexia group, and 35% of children were assigned to the SCD group (see Figure 5.5). A multinomial logistic regression analysis was conducted. Tests that assessed language comprehension ability (BPVS-III; χ^2 = 56.837, $p < .001$), decoding ability (Burt; χ^2 = 12.717, $p = .002$), and phonological awareness (Elision; χ^2 = 29.606, $p < .001$) contributed significantly to the model. Group membership was predicted accurately for 74.6% of all cases in the dyslexia group and 72.6% of all cases in the SCD group. Under half (44.9%) of all cases in the mixed difficulty group were accurately predicted. As a result, only 64.1% of all children were accurately assigned using this approach. This indicates that classifying children using the significant difference approach is not an improvement on the cluster analysis approach.

Table 5.5 reports the parameter estimates for the models that compared the mixed difficulty and SCD groups with the dyslexia groups. The odds ratios indicate that the risk of an outcome falling in the SCD and mixed difficulty groups, relative to the dyslexia group, increases as scores on the Elision and Burt tests increase and scores on the BPVS-III decrease.

Figure 5.5

Significant Difference Approach

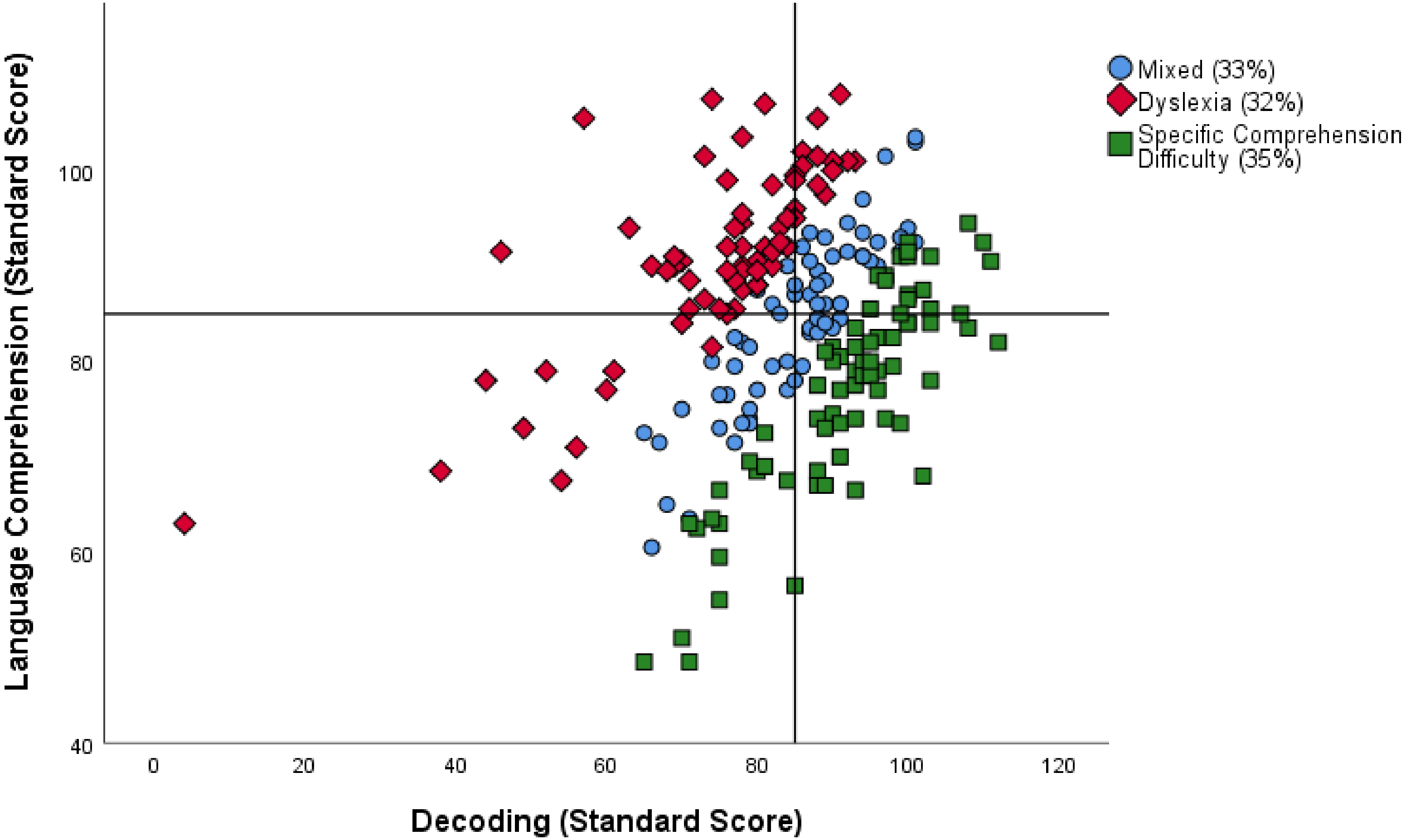


Table 5.5

Parameter Estimates for the Significant Difference Approach

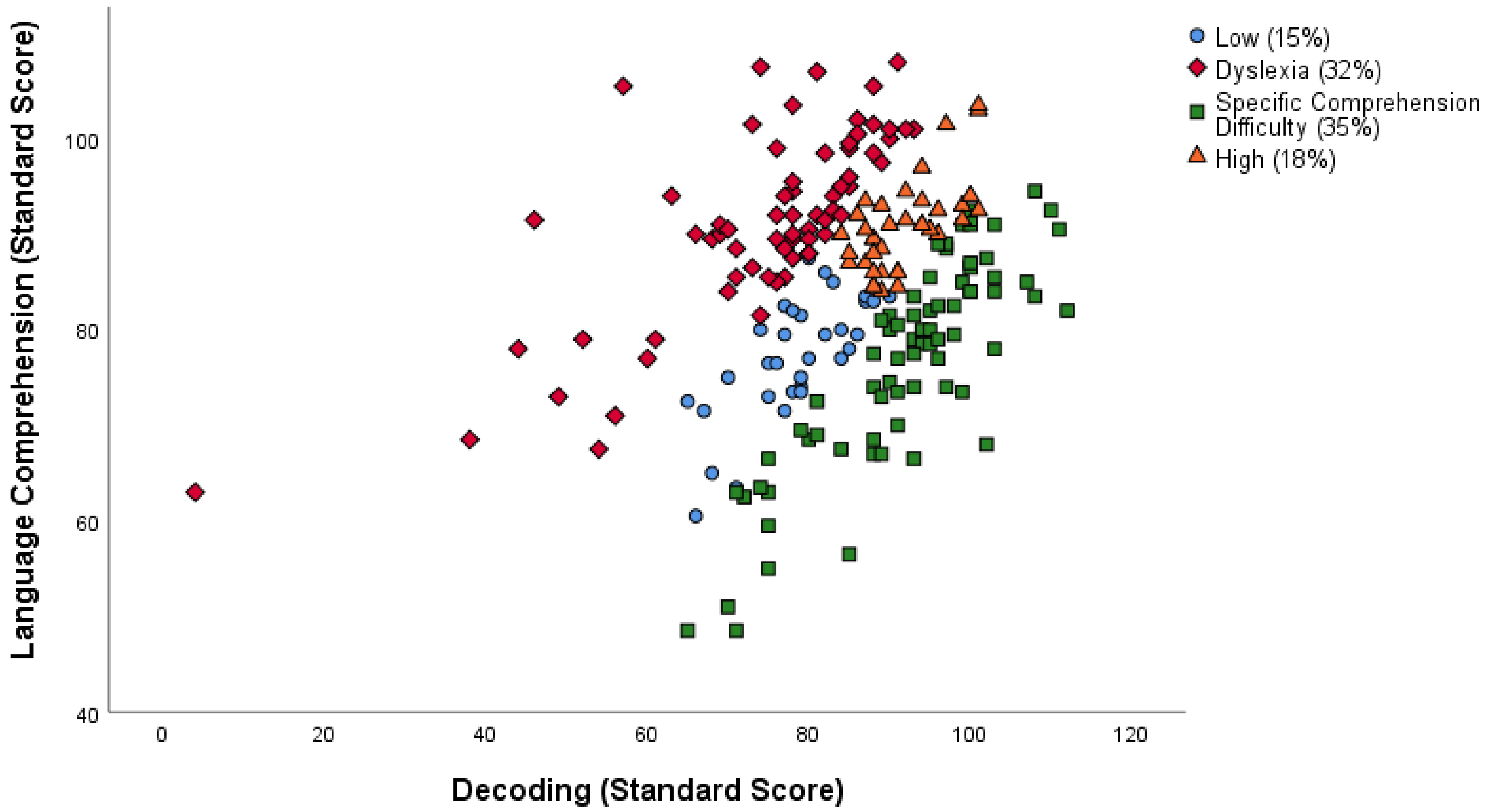
Group		*B*	*SE*	Wald	*df*	Sig.	Exp(*B*)	95% CI for Exp(*B*)	
								Lower limit	Upper limit
Mixed Difficulty	Intercept	−3.601	2.280	2.495	1	.114			
	Elision	**.064**	**.026**	**6.151**	**1**	**.013**	**1.066**	**1.014**	**1.121**
	Burt	**.068**	**.022**	**9.382**	**1**	**.002**	**1.070**	**1.025**	**1.117**
	BPVS-III	**−.083**	**.021**	**16.462**	**1**	**.000**	**.920**	**.884**	**.958**
Specific Comprehension Difficulty	Intercept	−4.908	2.722	3.252	1	.071			
	Elision	**.148**	**.031**	**22.738**	**1**	**.000**	**1.159**	**1.091**	**1.232**
	Burt	**.083**	**.027**	**9.152**	**1**	**.002**	**1.086**	**1.030**	**1.146**
	BPVS-III	**−.175**	**.029**	**36.342**	**1**	**.000**	**.839**	**.793**	**.888**

Note. The reference category is Dyslexia.

The mixed difficulty group that was identified using the significant difference approach included some children who performed relatively well on both the decoding and language comprehension variables and some children who performed relatively poorly on these variables. An additional significant difference analysis was undertaken to determine whether splitting the mixed difficulty group into a high group and a low group improved the predictive utility of the model. This approach is referred to as the *four-group significant difference approach*. Children in the mixed difficulty group were assigned to the high mixed difficulty group if their score on both the decoding and language comprehension variables fell at or above the 16th percentile. Children in the mixed difficulty group with scores below this cut-off were assigned to the low mixed difficulty group. Using this approach, 32% of children were assigned to the dyslexia group, 35% of children were assigned to the SCD group, 15% were assigned to the low mixed difficulty group, and 18% were assigned to the high mixed difficulty group (see Figure 5.6).

Figure 5.6

Four-Group Significant Difference Approach



A multinomial logistic regression analysis was conducted. Tests that assessed language comprehension ability (BPVS-III; $\chi^2 = 64.746$, $p < .001$), decoding ability (Burt; $\chi^2 = 18.723$, $p < .001$), and phonological awareness (Elision; $\chi^2 = 30.932$, $p < .001$) contributed significantly to the model. This approach was not an improvement over the significant difference approach (three groups). Group membership was predicted accurately for 83.6% of all children in the dyslexia group and 76.7% of all children in the SCD group. In contrast, assignment to the low mixed difficulty group (15.6%) and the high mixed difficulty group (16.2%) could not be predicted accurately. As a result, only 58.9% of all children were accurately classified.

Table 5.6 reports the parameter estimates for the models that compared the low, SCD, and high groups with the dyslexia group. The odds ratios indicate that the risk of an outcome falling in the low group relative to the dyslexia group increases as scores on the BPVS-III decrease. The risk of an outcome falling in the SCD group, relative to the dyslexia group, increases as scores on the Elision and Burt tests increase and scores on the BPVS-III decrease. The final model shows that as scores on the Elision and Burt tests increase and scores on the BPVS-III decrease, the risk of an outcome falling in the high group, relative to the dyslexia group, increase.

Table 5.6

Parameter Estimates for the Four-Group Significant Difference Approach

Group		*B*	*SE*	Wald	*df*	Sig.	Exp(*B*)	95% CI for Exp(*B*)	
								Lower limit	Upper limit
Low	Intercept	3.660	2.926	1.564	1	.211			
	Elision	.051	.031	2.718	1	.099	1.053	.990	1.119
	Burt	.031	.028	1.293	1	.255	1.032	.978	1.089
	BPVS-III	**−.133**	**.029**	**20.389**	**1**	**.000**	**.875**	**.826**	**.927**
Specific Comprehension Difficulty	Intercept	−5.537	2.907	3.628	1	.057			
	Elision	**.150**	**.031**	**23.213**	**1**	**.000**	**1.162**	**1.093**	**1.236**
	Burt	**.086**	**.028**	**9.586**	**1**	**.002**	**1.089**	**1.032**	**1.150**
	BPVS-III	**−.173**	**.030**	**34.157**	**1**	**.000**	**.841**	**.794**	**.891**
High	Intercept	−11.576	2.993	14.962	1	.000			
	Elision	**.080**	**.030**	**7.201**	**1**	**.007**	**1.083**	**1.022**	**1.148**
	Burt	**.101**	**.027**	**14.098**	**1**	**.000**	**1.107**	**1.050**	**1.167**
	BPVS-III	**−.047**	**.023**	**4.078**	**1**	**.043**	**.954**	**.912**	**.999**

Note. The reference category is Dyslexia.

5.2.4 Summary

The results indicate that the cluster analysis approach provided the best explanation for children's reading difficulties. This classification approach identified the three poor reader groups predicted by the model. Multinomial logistic regression analyses found that group membership could be predicted more accurately using this approach than any of the other classification approaches.

5.3 Cognitive Profiles

The analyses reported here investigated whether the poor reader groups demonstrated distinct cognitive profiles. This was the focus of Research Question 2. The analyses in this section are based on the cluster analysis approach because this approach provided the best fit for the data. Tables 5.7a and 5.7b provide an overview of each group's performance on the 14 tests that were administered in this research. A one-way between-subjects multivariate ANOVA was carried out to assess the impact of group assignment on test performance. The between-subjects factor comprised the three poor reader groups: dyslexia, SCD, and mixed difficulty. The dependent variable comprised children's scores on the 14 tests that were administered in this research. There was a significant difference between the groups on the combined dependent variable, $F(28,380) = 20.581$, $p < .001$; Wilks's lambda = .158. Fourteen ANOVA were conducted to determine whether there was a significant difference between the groups on each of the tests. Where the assumption of equal variance was not satisfied, the results from Welch and Brown–Forsythe tests are also reported. Post hoc tests were conducted where significant differences were identified. Where equal variance was assumed, Tukey's honestly significant difference test was conducted. Games–Howell post hoc tests were conducted where equal variance was not assumed.

Table 5.7a

Comparisons by Poor Reader Group

Test	Group	*N*	*M*	*SD*	Significant differences
Passage Comp	Mixed	35	62.03	14.72	Mixed < Dyslexia[a]
$F(2,206) = 54.246$, $p < .001$	Dyslexia	81	79.95	9.24	Mixed < SCD[a]
Welch: $(2,79.898) = 26.729$, $p < .001$	SCD	93	81.10	7.32	
Brown–Forsythe: $(2,68.798) = 38.385$, $p < .001$					
Word Attack	Mixed	35	66.89	17.62	Mixed < Dyslexia[a]
$F(2,206) = 91.312$, $p < .001$	Dyslexia	81	81.53	8.74	Mixed < SCD[a]
Welch: $(2,80.379) = 72.806$, $p < .001$	SCD	93	94.61	8.78	Dyslexia < SCD[a]
Brown–Forsythe: $(2, 60.183) = 60.506$, $p < .001$					
Letter-Word Identification	Mixed	35	66.29	15.89	Mixed < Dyslexia[a]
$F(2,206) = 88.016$, $p < .001$	Dyslexia	81	82.00	9.34	Mixed < SCD[a]
Welch: $(2,80.414) = 64.280$, $p < .001$	SCD	93	92.73	8.05	Dyslexia < SCD[a]
Brown–Forsythe: $(2,66.524) = 61.399$, $p < .001$					
Burt	Mixed	35	73.68	8.54	Mixed < Dyslexia[a]
$F(2,206) = 25.716$, $p < .001$	Dyslexia	81	82.54	9.91	Mixed < SCD[a]
	SCD	93	91.74	8.69	Dyslexia < SCD[a]
Word Reading Fluency	Mixed	32	75.25	9.79	Mixed < Dyslexia[c]
$F(2,203) = 25.438$, $p < .001$	Dyslexia	81	85.77	11.95	Mixed < SCD[c]
	SCD	93	91.18	10.46	Dyslexia < SCD[c]
Oral Comprehension	Mixed	35	71.97	7.13	Mixed < Dyslexia[a]
$F(2,206) = 91.220$, $p < .001$	Dyslexia	81	96.05	7.13	Mixed < SCD[a]
Welch: $(2,82.511) = 90.537$, $p < .001$	SCD	93	82.16	9.43	Dyslexia > SCD[a]
Brown–Forsythe: $(2,74.533) = 69.929$, $p < .001$					
Oral Vocabulary	Mixed	35	63.00	12.78	Mixed < Dyslexia[a]
$F(2,206) = 99.554$, $p < .001$	Dyslexia	81	90.40	9.30	Mixed < SCD[a]
Welch: $(2,84.122) = 67.942$, $p < .001$	SCD	93	82.14	8.41	Dyslexia > SCD[a]
Brown–Forsythe: $(2,87.378) = 80.364$, $p < .001$					
BPVS-III	Mixed	35	74.83	6.94	Mixed < Dyslexia[a]
$F(2,206) = 32.904$, $p < .001$	Dyslexia	81	88.83	11.66	Mixed < SCD[a]
Welch: $(2,103.177) = 32.517$, $p < .001$	SCD	93	79.75	8.26	Dyslexia > SCD[a]
Brown–Forsythe: $(2,173.897) = 37.237$, $p < .001$					

Table 5.7b

Comparisons by Poor Reader Group

Test	Group	*N*	*M*	*SD*	Significant differences
Phonological Processing	Mixed	35	70.03	12.20	Mixed < Dyslexia[c]
$F(2,206) = 15.382$, $p < .001$	Dyslexia	81	81.28	11.93	Mixed < SCD[c]
	SCD	93	83.35	12.60	
Elision	Mixed	35	74.14	8.62	Mixed < Dyslexia[c]
$F(2,206) = 57.750$, $p < .001$	Dyslexia	81	81.54	8.54	Mixed < SCD[c]
	SCD	93	91.77	9.52	Dyslexia < SCD[c]
Blending Words	Mixed	35	72.29	13.08	Mixed < Dyslexia[c]
$F(2,206) = 10.784$, $p < .001$	Dyslexia	81	83.15	13.750	Mixed < SCD[c]
	SCD	93	83.60	12.10	
Phoneme Isolation	Mixed	35	75.71	9.17	Mixed < Dyslexia[a]
$F(2,206) = 10.863$, $p < .001$	Dyslexia	81	86.54	13.22	Mixed < SCD[a]
Welch: (2,101.270) = 13.390, $p < .001$	SCD	93	83.12	10.60	
Brown–Forsythe: (2,173.949) = 11.976, $p < .001$					
Rapid Digit Naming	Mixed	35	85.14	9.81	Mixed < SCD[c]
$F(2,206) = 23.228$, $p < .001$	Dyslexia	81	89.69	8.56	Dyslexia < SCD[c]
	SCD	93	96.99	10.59	
Rapid Letter Naming	Mixed	35	84.71	9.70	Mixed < SCD[c]
$F(2,206) = 22.420$, $p < .001$	Dyslexia	81	88.70	8.02	Dyslexia < SCD[c]
	SCD	93	95.38	9.42	

Note. Significant differences between groups are recorded in the right-hand column. Greater than and less than signs denote the direction of these differences.

[a]Significant difference identified using both Tukey’s honestly significant difference and Games–Howell Post hoc tests.

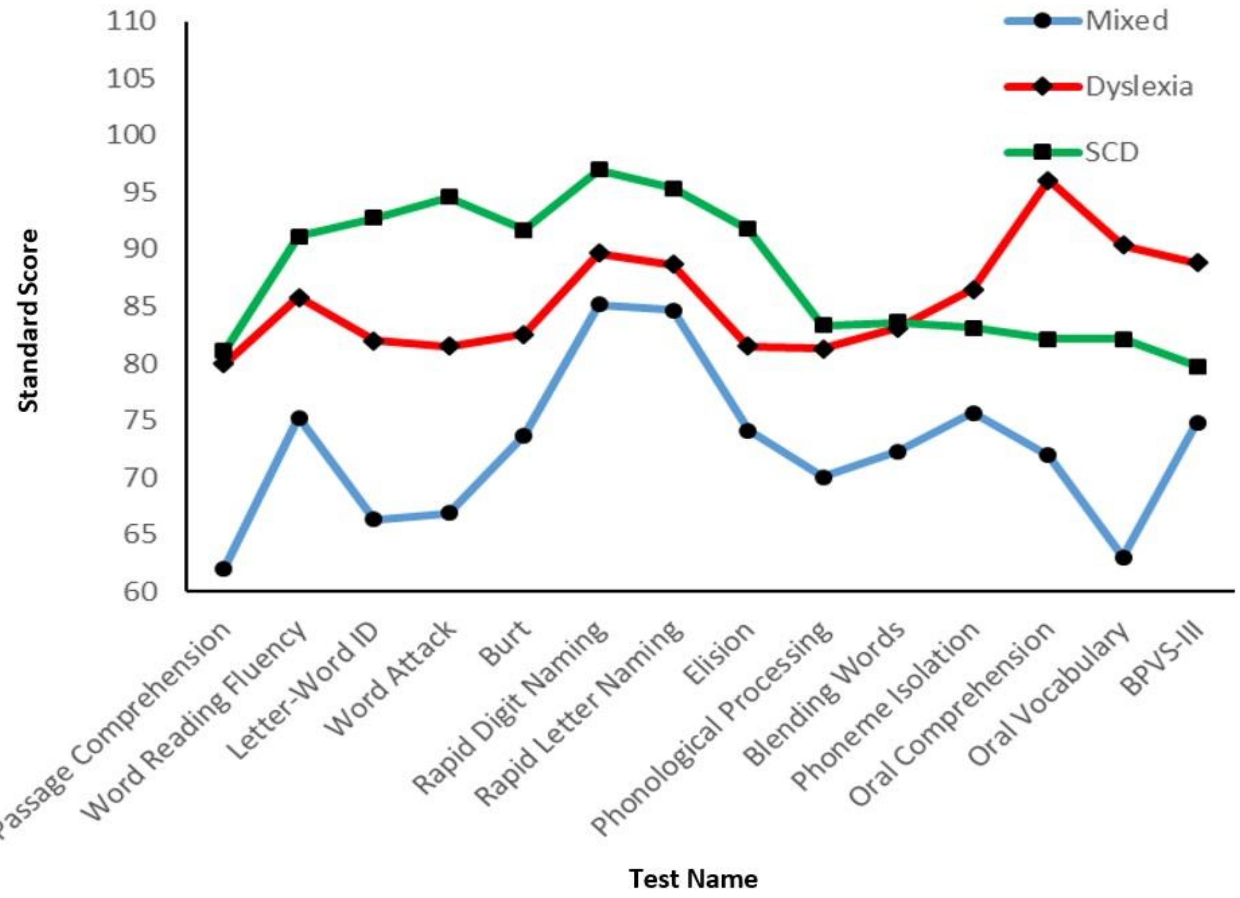
[b]Significant difference identified using Games–Howell post hoc test only.

[c] Significant difference identified using Tukey’s honestly significant difference post hoc test only.

The dyslexia group performed significantly better than the SCD group on the Oral Comprehension, Oral Vocabulary, and BPVS-III tests. The SCD group performed significantly better than the dyslexia group on the Word Attack, Letter-Word Identification, Word Reading Fluency, Elision, Rapid Digit Naming, Rapid Letter Naming, and Burt tests. In summary, the dyslexia group exhibited greater difficulties than the SCD group on tests that assessed decoding, rapid naming, and phoneme manipulation ability. The SCD group demonstrated greater difficulties on the tests that assessed language comprehension ability. While these groups exhibited distinct cognitive profiles, they performed at a similar level on the reading comprehension test. Both groups performed around the 9th percentile on this test. The mixed difficulty group demonstrated pronounced reading comprehension difficulties. Their average standard score placed them within the bottom first percentile on this test. They also performed significantly worse than the SCD group on every test and significantly worse than the dyslexia group on all but the two rapid naming tests. The relative strengths and weaknesses exhibited by these groups can be seen in Figure 5.7. This figure is based on the results reported in Tables 5.7a and 5.7b.

Figure 5.7

Poor Reader Profiles



The reading comprehension difficulties exhibited by the mixed difficulty group are consistent with those predicted by the SVR. Children with more pronounced decoding and language comprehension difficulties are expected to exhibit greater reading comprehension difficulties. A multiple regression analysis confirmed this relationship. In total, decoding and language comprehension ability explained 66.4% of the variance in reading comprehension ability ($F(2,206) = 203.943$, $p < .001$). Additional multiple regression analyses were undertaken using the sum ($F(1,207) = 368.469$, $p < .001$, $r^2 = .64$) and product ($F(1,207) = 328.877$, $p < .001$, $r^2 = .61$) of decoding and language comprehension as the independent variable. As expected, both models explained a similar proportion of the variance in reading comprehension. These figures fell within the range predicted by the meta-analysis reported in the literature review section of this thesis (57% to 68%).

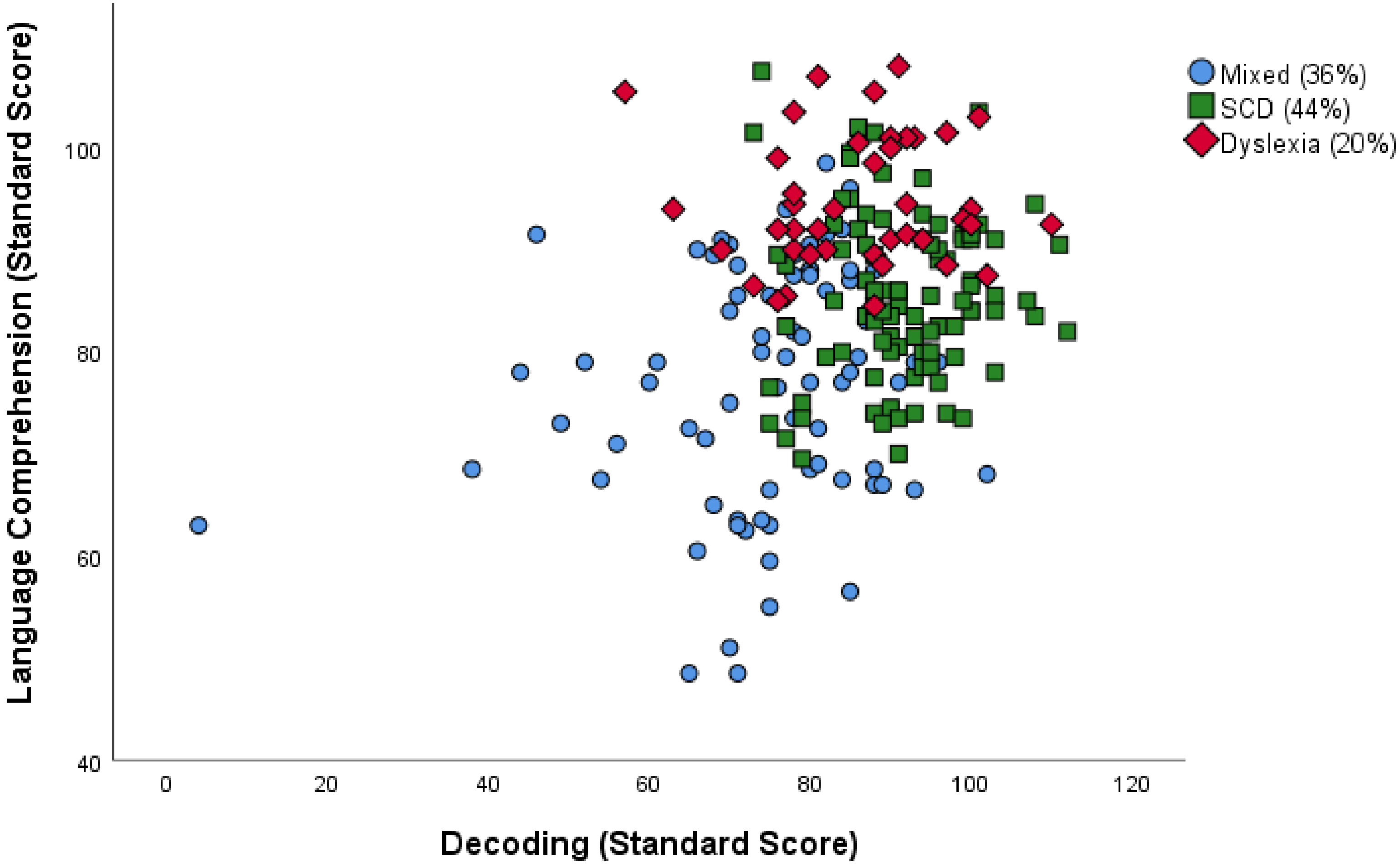
5.4 Secondary Classification Analyses

The analyses reported here relate to Research Question 3. This question investigated whether tests with teacher-level restrictions could also be used to classify poor readers. In the current analyses, decoding ability was assessed using the Burt test and language comprehension ability was assessed using the BPVS-III. Analyses indicated a strong correlation between the Burt test and the decoding variable ($r = .767$, $N = 209$, $p < .001$) and between the BPVS-III and the language comprehension variable ($r = .624$, $N = 209$, $p < .001$). This confirms the predicted positive relationship between these variables.

To investigate whether classification based on these tests resulted in groupings similar to previous analyses, a cluster analysis was conducted. From this point forward, this analysis is referred to as the *secondary cluster analysis approach*. The Burt and BPVS-III tests were entered into the analysis. As in the previous analyses, log likelihood was used as the distance measure and the analysis software program was allowed to determine the optimal number of groupings. This resulted in three poor reader groups being identified and 36% of children being assigned to the mixed difficulty group, 20% of children assigned to the dyslexia group, and 44% of children assigned to the SCD group. Every child was classified using this approach in Figure 5.8. Each marker represents one child's score on the decoding and language comprehension variables. If there was a perfect relationship between the secondary cluster analysis approach and the optimal cluster analysis approach (see Figure 5.2), all the markers in the bottom left-hand corner would be blue, markers in the top left would be red, and markers in the bottom right would be green. This would indicate that children were assigned to the same category using both approaches. A small number of green squares fall within the blue dots. This indicates that when these children were classified using the secondary cluster analysis approach, they were assigned to the SCD group. However, when they were classified using the cluster analysis approach, they were assigned to the mixed difficulty group. A number of green squares and blue circles appear within the upper left-hand corner. Respectively, these children were assigned to the SCD and mixed difficulty groups in the secondary cluster analysis approach but were assigned to the dyslexia group in the cluster analysis approach. A larger proportion of children were assigned to the mixed difficulty group using the secondary cluster analysis approach (36%) than under the primary cluster analysis approach (17%). Table 5.8 reports the proportion of children who were assigned to the same poor reader groups across the cluster analysis and secondary cluster analysis approaches. In total, 62% of children were assigned to the same poor reader groups. A similar proportion of poor readers were assigned to the mixed difficulty (89%) and SCD (71%) groups across the cluster analysis and secondary cluster analysis approaches. These results indicate consistency across the classification approaches. In contrast, only 40% of children assigned to the dyslexia group using the cluster analysis approach were assigned to this group using the secondary cluster analysis approach.

Figure 5.8

Secondary Cluster Analysis Approach (Burt Test and BPVS-III)



Some children who were assigned to the dyslexia group using the cluster analysis approach were assigned to either the SCD or the mixed difficulty group in the secondary cluster analysis approach. This indicates that some children who were assigned to the dyslexia group using the cluster analysis approach performed more poorly on the BPVS-III test than they did on the composite language comprehension variable used in the cluster analysis approach. As a result, these children were assigned to the mixed difficulty group in the secondary cluster analysis. There were also some children who were assigned to the dyslexia group in the cluster analysis approach who were assigned to the SCD group in the secondary cluster analysis approach. This change is more surprising because these groups exhibit opposite profiles. It suggests that, for some children, the secondary assessments do not accurately capture their decoding and language comprehension ability. This may be because the Burt and BPVS-III tests provide a narrow assessment of decoding and language comprehension ability. The Burt test only assessed word recognition ability. However, the decoding variable used in the cluster analysis approach was derived from tests that assessed word identification and word attack ability. The BPVS-III only measures receptive vocabulary ability. In contrast, the language comprehension variable used in the cluster analysis approach was based on tests that assessed vocabulary knowledge and oral comprehension ability.

Table 5.8

Assignment Comparison between the Cluster Analysis Approach and the Secondary Cluster Analysis Approach

		Cluster analysis groupings		
		Mixed	SCD	Dyslexia
Secondary Cluster Analysis Groupings	Mixed	89%	11%	0%
	SCD	19%	71%	10%
	Dyslexia	32%	28%	40%

Two additional cluster analyses were performed to determine whether group assignment could be predicted more accurately if a third variable was added to the analysis. The secondary cluster analysis assigned a relatively large proportion of children in the dyslexia group to the incorrect poor reader group. In the first analysis, the Elision test, which assessed phoneme deletion ability, was entered into the analysis along with the Burt and BPVS-III tests. The second cluster analysis included the Burt, BPVS-III, and Passage Comprehension tests. These analyses were not an improvement on the cluster analysis that included only the Burt and BPVS-III tests. The dyslexia group was predicted correctly in 36% of cases when the Elision test was added to the analysis and in 37% of all cases when the Passage Comprehension test was included in the analysis. This suggests that efforts to obtain tests that teachers can administer that assess reading comprehension and phoneme deletion ability are unlikely to improve the accuracy with which membership to the dyslexia group can be predicted.

The poor reader groups that were identified using the secondary cluster analysis approach were compared across the 14 assessments. First, a one-way between-subjects multivariate ANOVA was carried out to assess the impact of group assignment on test performance. The between-subjects factor comprised the three poor reader groups: dyslexia, SCD, and mixed difficulty. The dependent variable comprised children's scores on the 14 tests that were administered in this research. There was a significant difference between the groups on the combined dependent variable, $F(28,380) = 21.663$, $p < .001$; Wilks's lambda = .148. Fourteen ANOVA were conducted to determine whether there was a significant difference between the groups on each of the tests. The results from these comparisons are displayed in Tables 5.9a and 5.9b. Where ANOVA indicated there were significant differences between groups, post hoc tests were performed. Welch and Brown–Forsythe tests are reported for tests where the assumption of equal variance was not satisfied. In these cases, Games–Howell post hoc tests were conducted. Tukey's honestly significant difference test was conducted for tests where equal variance was assumed.

The dyslexia group performed significantly better than the SCD group on all of the language comprehension tests (Oral Comprehension, Oral Vocabulary, and BPVS-III tests) and significantly worse than the SCD group on two of the three decoding assessments (Word Attack and Burt tests). They exhibited greater difficulties than the SCD group on the Letter-Word Identification test but this difference was not significant. The dyslexia group also performed significantly worse than the SCD group on the Elision and Rapid Letter Naming tests. This pattern of strengths and weaknesses is consistent with that observed in the previous comparisons based on the cluster analysis approach (see Tables 5.7a and 5.7b). The mixed difficulty group also exhibited a similar profile. They performed significantly worse than the SCD group on every assessment and significantly worse than the dyslexia group on 12 of the 14 assessments. They performed at a similar level to the dyslexia group on the Rapid Naming tests.

Table 5.9a

Comparisons by Poor Reader Group (Secondary Assessments)

Test	Group	*N*	*M*	*SD*	Significant differences
Passage Comp	Mixed	75	68.99	13.57	Mixed < Dyslexia[a]
$F(2,206) = 41.631$, $p < .001$	Dyslexia	41	82.00	8.86	Mixed < SCD[a]
Welch: $(2,94.027) = 30.767$, $p < .001$	SCD	93	82.29	6.60	
Brown–Forsythe: $(2,143.297) = 40.898$, $p < .001$					
Word Attack	Mixed	75	74.81	15.86	Mixed < Dyslexia[a]
$F(2,206) = 43.609$, $p < .001$	Dyslexia	41	85.63	9.83	Mixed < SCD[a]
Welch: $(2,106.289) = 37.369$, $p < .001$	SCD	93	92.71	9.89	Dyslexia < SCD[a]
Brown–Forsythe: $(2,160.885) = 45.441$, $p < .001$					
Letter-Word Identification	Mixed	75	74.39	14.41	Mixed < Dyslexia[a]
$F(2,206) = 43.346$, $p < .001$	Dyslexia	41	86.20	12.20	Mixed < SCD[a]
Welch: $(2,) = 92.70$, $p < .001$	SCD	93	91.11	8.59	
Brown–Forsythe: $(2,169.216) = 81.689$, $p < .001$					
Burt	Mixed	75	75.30	6.91	Mixed < Dyslexia[a]
$F(2,206) = 114.171$, $p < .001$	Dyslexia	41	84.07	10.69	Mixed < SCD[a]
Welch: $(95.167) = 143.432$, $p < .001$	SCD	93	93.57	6.96	Dyslexia < SCD[a]
Brown–Forsythe: $(2,96.443) = 93.245$, $p < .001$					
Word Reading Fluency	Mixed	72	78.65	10.08	Mixed < Dyslexia[c]
$F(2,203) = 31.307$, $p < .001$	Dyslexia	41	88.73	13.27	Mixed < SCD[c]
	SCD	93	91.76	9.96	
Oral Comprehension	Mixed	75	79.61	14.55	Mixed < Dyslexia[a]
$F(2,206) = 27.452$, $p < .001$	Dyslexia	41	96.24	7.78	Mixed < SCD[a]
Welch: $(2,117.807) = 36.325$, $p < .001$	SCD	93	86.27	10.19	Dyslexia > SCD[a]
Brown–Forsythe: $(2,170.130) = 30.435$, $p < .001$					
Oral Vocabulary	Mixed	75	72.97	13.80	Mixed < Dyslexia[a]
$F(2,206) = 48.303$, $p < .001$	Dyslexia	41	93.22	9.037	Mixed < SCD[a]
Welch: $(2,107.856) = 44.993$, $p < .001$	SCD	93	84.63	9.36	Dyslexia > SCD[a]
Brown–Forsythe: $(2,166.811) = 50.425$, $p < .001$					
BPVS-III	Mixed	75	75.83	6.90	Mixed < Dyslexia[c]
$F(2,206) = 179.301$, $p < .001$	Dyslexia	41	99.56	7.12	Mixed < SCD[c]
	SCD	93	80.24	6.17	Dyslexia > SCD[c]

Table 5.9b

Comparisons by Poor Reader Group (Secondary Assessments)

Test	Group	*N*	*M*	*SD*	Significant differences
Phonological Processing	Mixed	75	74.09	13.05	Mixed < Dyslexia[c]
$F(2,206) = 14.997$, $p < .001$	Dyslexia	41	83.66	12.58	Mixed < SCD[c]
	SCD	93	83.87	11.53	
Elision	Mixed	75	78.80	9.15	Mixed < Dyslexia[a]
$F(2,206) = 25.852$, $p < .001$	Dyslexia	41	84.27	8.77	Mixed < SCD[a]
Welch: (2,112.993) = 25.321, $p < .001$	SCD	93	90.00	11.21	Dyslexia < SCD[a]
Brown–Forsythe: (2,183.071) = 28.219, $p < .001$					
Blending Words	Mixed	75	75.60	12.16	Mixed < Dyslexia[c]
$F(2,206) = 12.853$, $p < .001$	Dyslexia	41	83.54	12.36	Mixed < SCD[c]
	SCD	93	85.43	13.49	
Phoneme Isolation	Mixed	75	78.33	10.18	Mixed < Dyslexia[c]
$F(2,206) = 12.022$, $p < .001$	Dyslexia	41	88.41	13.34	Mixed < SCD[c]
	SCD	93	84.84	11.48	Dyslexia > SCD[c]
Rapid Digit Naming	Mixed	75	88.93	10.14	Mixed < SCD[c]
$F(2,206) = 8.041$, $p < .001$	Dyslexia	41	91.10	8.405	
	SCD	93	95.27	11.26	
Rapid Letter Naming	Mixed	75	87.87	9.56	Mixed < SCD[c]
$F(2,206) = 10.589$, $p < .001$	Dyslexia	41	89.27	8.70	Dyslexia < SCD[c]
	SCD	93	94.30	9.57	

Note. Significant differences between groups are recorded in the right-hand column. Greater than and less than signs denote the directions of these differences.

[a]Significant difference identified using both Tukey's honestly significant difference and Games–Howell Post hoc tests.

[b]Significant difference identified using Games–Howell post hoc test only.

[c] Significant difference identified using Tukey's honestly significant difference post hoc test only.

The previous analyses indicate that the secondary cluster analysis approach, based on the Burt test and BPVS-III, provides a good approximation of the poor reader groups identified using the cluster analysis approach. However, it is unlikely that teachers will be able to apply this cluster analysis approach within their own classes because this approach requires a large number of children and it is likely that teachers have little experience with cluster analyses. Table 5.10 reports the average raw scores obtained by each poor reader group on the Burt test and the BPVS-III by year level. These results are based on the groups identified using the cluster analysis approach because this was found to be the optimal classification approach. Teachers could use this information to determine whether a child's reading difficulties are primarily due to decoding or language comprehension difficulties. For example, a Year 6 child who obtained a raw score greater than 119 on the BPVS-III and a raw score less than 61 on the Burt test may benefit from a reading programme with an increased focus on decoding because that child's profile is characteristic of a child who exhibits the dyslexia profile. While further testing would be required for a formal diagnosis of dyslexia, this simple analysis of raw scores may be sufficient to identify the proximal cause of a child's reading difficulties.

Table 5.10

Burt and BPVS Raw Scores

		Year 4		Year 5		Year 6	
		N	*M* (95% CI)	*N*	*M* (95% CI)	*N*	*M* (95% CI)
Mixed	Burt	9	26 (22–30)	13	33 (26–40)	13	36 (26–45)
	BPVS-III	9	82 (65–99)	13	94 (83–105)	13	104 (97–110)
Dyslexia	Burt	27	36 (32–40)	22	41 (36–46)	32	56 (51–61)
	BPVS-III	27	108 (103–113)	22	116 (110–121)	32	123 (119–127)
SCD	Burt	20	45 (41–49)	37	57 (54–60)	36	68 (64–72)
	BPVS-III	20	94 (88–99)	37	105 (101–109)	36	113 (109–118)

5.5 Summary

The results indicate that the cluster analysis approach provided a better explanation for children's reading difficulties than all the other classification approaches, including the traditional classification approach. The cluster analysis approach was able to accurately assign children to one of the three poor reader groups predicted by the SVR model: dyslexia, SCD, and mixed difficulty. Compared with children in the SCD group, the dyslexia group exhibited significant decoding, rapid naming, and phoneme deletion difficulties. In contrast, they performed significantly better than the SCD group on tests that assessed language comprehension ability. The mixed difficulty group did not exhibit any relative strengths. They performed at low levels on all the tests that were administered and demonstrated substantial difficulties on tests that assessed reading comprehension and knowledge of synonyms and antonyms.

The secondary cluster analysis approach, which was based on the Burt and BPVS-III tests, identified the same poor reader groups predicted by the SVR. Analyses compared this approach with the cluster analysis approach that was based on the decoding and language comprehension variables. These analyses indicated that most children were assigned to the same poor reader category across classification approaches. However, limitations were identified. A relatively large proportion of children assigned to the dyslexia group were not accurately classified using the secondary cluster analysis approach. Some children in the dyslexia group were assigned to the mixed or SCD group, and a relatively large proportion of children moved from the SCD group to the mixed difficulty group in the secondary cluster analysis approach.

Chapter 6 Discussion

This chapter starts by summarising the key findings from this research in relation to the three research questions that were posed at the start of the thesis. It then considers the evidence for a three-group classification approach. Next, this chapter examines what proportion of children with reading difficulties exhibit each of the poor reader profiles before comparing and contrasting the cognitive profiles exhibited by those groups of struggling readers. It then examines whether the secondary assessments used in this research are suitable for classification purposes within an education setting and discusses the educational implications associated with key findings from this research. Finally, the chapter acknowledges limitations associated with this study and identifies areas for future investigation that have evolved from this research.

6.1 Summary of Key Findings

This research sought to investigate whether there is a better way to classify poor readers than the traditional classification approach, which uses cut-off points to assign poor readers to four poor reader categories. It then explored whether the poor reader groups that were identified, in the best classification model, exhibited distinct cognitive profiles. Finally, it examined whether tests with teacher-level restrictions could be used to identify the three poor reader groups predicted by the SVR. To answer these questions, a wide range of assessments were administered to 209 poor readers in Years 4, 5, and 6. These individually administered tests assessed each child’s reading comprehension ability and their proficiency on a range of cognitive processes that are associated with this skill. The following paragraphs briefly summarise the key findings related to these questions.

The results section explored a number of classification approaches; these included the traditional classification approach, classification based on cluster analyses, and classification based on significant differences. These analyses found that alternative classification approaches could provide a better fit for the data than the traditional classification approach. The cluster analysis approach provided the best explanation for the data. This approach found that children could be assigned to one of three poor reader groups. Children were assigned to the dyslexia, SCD, or mixed difficulty group based on their decoding and language comprehension ability. Children who primarily exhibited decoding difficulties were assigned to the dyslexia group, and children who primarily exhibited language comprehension difficulties were assigned to the SCD group. Children who exhibited decoding and language comprehension difficulties were assigned to the mixed difficulty group. A multinomial logistic regression analysis confirmed that this approach provided a better explanation for the data than the traditional classification approach.

A valid classification approach should be able to differentiate between groups of poor readers (Catts et al., 2003). The second research question investigated whether classification approaches based on the SVR could be used for this purpose. Specifically, this question investigated whether a strengths and weaknesses profile analysis could be used to discriminate between groups of poor readers. The results indicated that the dyslexia, SCD, and mixed difficulty groups demonstrated distinct cognitive profiles. The extent to which a classification approach can discriminate between groups of poor readers is one factor that is considered when evaluating the efficacy of a classification approach.

The third question considered whether classifying children using the BPVS-III and Burt tests resulted in groupings similar to those obtained using the decoding and language comprehension variables. The results confirmed that these tests aligned closely with the decoding and language comprehension measures used in this research. A cluster analysis based on these tests identified the same poor reader groups predicted by the SVR model. This analysis found that a similar proportion of children were assigned to each poor reader group using the cluster analysis and the secondary cluster analysis approaches. A further analysis indicated that 62% of children were assigned to the same poor reader groups across these analyses.

6.2 Evidence for a Three-Group Model

The proportion of children assigned to each poor reader category is influenced by the classification approach that is adopted. One of the factors that has the greatest effect on the proportion of children assigned to each category is the number of categories that are required to explain children's reading difficulties. The traditional classification approach identifies four groups of poor readers. Three of these groups demonstrate difficulties on one or both of the decoding and language comprehension variables. The fourth group are postulated to exhibit limited reading comprehension ability in the absence of decoding and language comprehension difficulties. A three-group classification model eliminates the need for this category. Instead, it predicts that children assigned to the unexplained poor reader category can be assigned to one of the other three poor reader groups. The results indicated that the cluster analysis classification approach provided a better explanation for children's reading difficulties than any of the other classification approaches. This approach identified the three poor reader groups predicted by the SVR model. An additional cluster analysis confirmed that three groups, rather than four groups, also provided a better fit for the data when weighted decoding and weighted language comprehension scores were used, and a further cluster analysis identified three groups using different decoding (Burt test) and language comprehension (BPVS-III) measures.

The significant difference classification approach also identified three groups of poor readers. This approach was able to identify and differentiate between children with dyslexia (73%) and those with SCD (73%). However, compared with the cluster analysis approach (74.3%), it was not able to accurately identify children exhibiting the mixed difficulty profile

(43%). This approach was not considered a valid classification methodology because it does not accurately classify all poor readers.

6.3 Prevalence

The children were not evenly distributed among the three poor reader groups. Some poor reader profiles occurred more frequently than others. Multinomial logistic regression analyses indicated that the cluster analysis approach provided the best overall fit for the data. Notwithstanding this finding, some other approaches were able to accurately identify specific groups of struggling readers with a similar level of accuracy. For this reason, all classification approaches described in the results section are considered here when determining prevalence rates for each poor reader group.

6.3.1 Dyslexia

Between 22% and 35% of poor readers were assigned to the dyslexia group across the four-group classification approaches. The four-group cluster analysis approach assigned the greatest proportion of children to the dyslexia category (35%). The multinomial logistic regression analyses indicated that this was the most accurate of all the four-group classification approaches. The traditional classification approach assigned the smallest proportion of poor readers to the dyslexia category (22%), but also showed evidence of being the least accurate of all the classification approaches. This may be because this form of classification approach is very sensitive to the placement of cut-off lines, whereas cluster analysis approaches do not use cut-off lines and so are not susceptible to this limitation.

Both of the three-group classification approaches assigned more than 30% of poor readers to the dyslexia category. It is expected that a three-group classification approach will identify a larger proportion of children with dyslexia because the children that are assigned to the unexplained poor reader category in a four-group classification approach must be distributed to one of the other three poor reader categories. This means that some children who were previously assigned to the unexplained poor reader category are likely to be assigned to the dyslexia category in a three-group classification approach.

The significant difference classification approach assigned 32% of the poor readers to the dyslexia category. This approach has a limitation similar to that of the traditional classification approach. Whereas the traditional classification approach is sensitive to the placement of cut-off lines, the significant difference approach is sensitive to the confidence interval used to classify poor readers. The cluster analysis approach (three groups) assigned the greatest proportion of poor readers to the dyslexia group (39%). This approach is not susceptible to the same limitations as those of the significant difference approach because cluster analyses aim to maximise homogeneity within groups. Subsequent analyses (including the multinomial logistic regression and group-differences analyses) suggested that the cluster analysis approach identified children exhibiting a dyslexia profile.

6.3.2 SCD

Compared with the dyslexia group, a similar proportion of the poor readers were assigned to the SCD category across all classification approaches. As expected, the greatest proportion of poor readers were assigned to the SCD category in the three-group classification approaches. The significant difference approach assigned 35% of poor readers to the SCD category. A greater proportion of children were assigned to this category using the three-group cluster analysis approach (44%). The significant difference and three-group cluster analysis approach assigned a slightly different mix of children to this category. All of the children assigned to the SCD category in the significant difference approach demonstrated significantly greater difficulty on the language comprehension variable than the decoding variable. However, some of these children exhibited limited proficiency on both of these variables. In the cluster analysis approach, a number of these children were assigned to the mixed difficulty group. In addition, some children performed relatively well on both variables. If there was no significant difference between a child’s scores on these variables, the child was assigned to the mixed difficulty group using the significant difference approach. Some of these children were assigned to the SCD group using the cluster analysis approach. Nevertheless, most children who were assigned to the SCD category using the significant difference approach were also assigned to this category using the cluster analysis approach.

Between 24% and 35% of all poor readers were assigned to the SCD group across the four-group classification approaches. The smallest proportion of readers (24%) were assigned to the SCD category using the traditional classification approach. The multinomial logistic regression analyses indicated that the traditional classification approach and the four-group cluster analysis approach predicted assignment to the SCD group with a similar level of accuracy. The four-group significant difference approach assigned a similar proportion of children to the SCD group (35%). However, the multinomial logistic regression analysis indicated that this approach provided a far better explanation for the data than the traditional classification approach. These analyses suggest that when establishing prevalence rates, it is important to look beyond whether there is consistency across approaches. Analyses should also evaluate the accuracy of a classification approach. For example, two approaches may assign a similar proportion of children to a poor reader category. However, the actual children assigned to these groups may vary considerably across approaches.

The results indicate that the proportion of poor readers assigned to the SCD category was similar to those assigned to the dyslexia category across all classification approaches. The pattern of assignment was also similar. For example, the smallest proportion of children were assigned to the SCD and dyslexia categories using the traditional classification approach and the largest proportion of children were assigned to these categories using the cluster analysis approach (three groups).

6.3.3 Mixed Difficulty

Between 13% and 23% of all readers were assigned to the mixed difficulty category across the four-group classification approaches. There was greater variation across the three-group classification approaches. The significant difference classification approach assigned 33% of poor readers to the mixed difficulty category. This proportion is substantially larger than the proportion of children assigned to the mixed difficulty category in any other classification approach. In addition, the multinomial logistic regression analysis indicated that this approach was not able to accurately identify children exhibiting the mixed difficulty profile. The significant difference classification approach also identified a different group of poor readers to those of the other classification approaches. In the other classification approaches, children in the mixed difficulty group exhibited limited proficiency on both the decoding and the language comprehension variables. In contrast, children assigned to the mixed difficulty category in the significant difference approach were those children who obtained a score on the decoding variable that was not significantly different from their score on the language comprehension variable. This meant that the mixed difficulty group in this classification approach included children who performed poorly on both variables and children who performed relatively well on both variables. The other classification approaches assigned children who performed relatively well on the decoding and language comprehension variables to the other poor reader categories. All of the other classification approaches that did not group children according to significant differences were able to accurately identify a group of children who exhibited the mixed difficulty profile. These children performed poorly on both the decoding and the language comprehension variables.

6.3.4 Summary

The classification approaches indicate that between 22% and 39% of the poor readers in this study could be assigned to the dyslexia group. The 22% figure (traditional classification approach) may underestimate the prevalence of dyslexia in this sample because the other approaches assigned more than 30% of poor readers to this category. According to the multinomial logistic regression analyses, it was also the least accurate of all the classification approaches. Excluding the traditional classification approach, between 30% and 39% (depending on the classification approach) of the children exhibited the dyslexia profile. If this group of poor readers (lowest 40th percentile, 0.4) is representative of all poor readers, between 12% ($.30 \times .40 = .12$) to 16% ($.39 \times .40 = .156$) of all children would be expected to exhibit the dyslexia profile. This rate is consistent with prevalence rates for dyslexia reported in other literature (American Psychiatric Association, 2013; Handler & Fierson, 2011; Shaywitz et al., 2008).

Compared with the dyslexia category, a similar proportion of children were assigned to the SCD category. The smallest proportion of children were assigned to the SCD category using the traditional classification approach (24%). The remaining approaches indicate that between 32% and 45% of poor readers exhibit the SCD reading profile. These approaches were able to identify children exhibiting the SCD profile with greater accuracy than the traditional classification approach. This means that, based on the most accurate figures, between 13% ($.32 \times .40 = .13$) and 18% ($.45 \times .40 = .18$) of all children in this age range may exhibit a profile consistent with SCD. Therefore, the analyses conducted in this research indicate that a similar proportion of Aotearoa New Zealand’s struggling readers exhibit either the dyslexia (12%-16%) or SCD (13%-18%) profile.

Between 13% and 24% of poor readers exhibited the mixed difficulty profile. This range excludes the proportion of children assigned to the mixed difficulty group in the significant difference classification approach where the mixed difficulty group included children who did not exhibit a significant difference between their decoding and language comprehension scores. In contrast, all the other classification approaches identified children who exhibited difficulties on both the decoding and the language comprehension variables. The results from these classification approaches indicate that approximately 5% (.13 × .40 = .05) to 10% (.24 × .40 = .10) of all children in this age range may exhibit the mixed difficulty profile.

A number of factors could influence the prevalence rates described above. For example, these rates are based on the assumption that the children who took part in this research are representative of all struggling readers within this age range in Aotearoa New Zealand. This research also assumes that the bottom 40% of the reading distribution are struggling readers. Use of a stricter cut-off point (e.g. the 25th percentile) might result in different prevalence rates. Some recent research suggests that prevalence rates should be conceptualised as a continuous distribution, rather than a single number (Wagner et al., 2020, 2021). Prevalence rates for dyslexia and SCD are predicted to vary depending on the severity of the difference between reading comprehension and language comprehension (SCD; Wagner et al., 2021) and reading comprehension and decoding (Dyslexia; Wagner et al., 2020). Notwithstanding this research and the limitations that have been identified, the prevalence rates reported in the current study indicate the proportion of children within Years 4, 5, and 6 classrooms in Aotearoa New Zealand that might exhibit each of the poor reader profiles predicted by the SVR.

6.4 Strengths and Weaknesses Profile Analysis

A valid classification approach should be able to differentiate between groups of poor readers (Catts et al., 2003). The results section compared the three poor reader groups across all the tests that were administered. These analyses identified relative strengths and weaknesses. The analyses confirmed that the poor reader groups demonstrated distinct cognitive profiles. In addition, the multinomial logistic regression analyses showed that it was possible to accurately discriminate between the three poor reader groups using only a small number of tests. For example, it was possible to accurately predict group assignment for the cluster analysis approach using the Burt (decoding), BPVS-III (language comprehension), Passage Comprehension (reading comprehension), and Elision (phoneme deletion) tests.

6.4.1 Dyslexia Group

Children in the dyslexia group performed significantly more poorly than children in the SCD group on the Word Attack, Letter-Word Identification, Word Reading Fluency, Burt, Rapid Digit Naming, Rapid Letter Naming, and Elision tests. In contrast, they performed significantly better than the SCD group on all the language comprehension measures (Oral Comprehension, Oral Vocabulary, and BPVS-III tests).

All the poor reader groups exhibited phonological awareness difficulties. However, the dyslexia group exhibited significantly greater difficulties than the SCD group on the phoneme deletion test (Elision test). Catts et al. (2003) found there was no difference between the dyslexia and SCD groups on the phonological awareness measure used in their study. This finding must be interpreted cautiously because the children in the research conducted by Catts and colleagues were in Grade 2 and the children in this study were in Years 4, 5, and 6 (Grades 3–5). It is possible that differences in phoneme deletion ability are more likely to be observed between the dyslexia and SCD groups in studies that include older participants than those included in Catts and colleagues' research. Lauterbach et al. (2017) found some evidence for this. They found that phonological awareness along with verbal comprehension and phonetic decoding ability could be used to discriminate between children with dyslexia and children with SLI. The participants in their study ranged in age from 7.01 to 20.06 years. They used the Elision test from the CTOPP-2 to assess phonological awareness. This test assesses children's ability to delete phonemes within a word to create a new word. It is the same phoneme deletion test that was used in this research. These findings indicate that care must be taken when operationally defining variables. For example, phonological awareness when operationalised through phoneme deletion measures may be able to discriminate between groups of children with dyslexia and those with SCD who are older than the participants in Catts and colleagues' research. However, tests that focus primarily on syllable deletion in younger age groups may not be able to differentiate between these groups.

The ability to identify and manipulate phonemes is essential for skilled decoding within an alphabetic orthography (Ehri, 2014; Wren, 2001). Children must be able to identify individual phonemes within words when developing mental representations of a word in their mind and when converting graphemes to phonemes when reading new or unfamiliar words (Arrow & Tunmer, 2012; Diamanti et al., 2018; Kendeou et al., 2014; Tunmer & Hoover, 2019). Because the ability to identify and manipulate phonemes is essential for skilled decoding, it is not surprising that children with dyslexia exhibit difficulties with this skill. In contrast, children who exhibit the SCD profile are less likely to exhibit phoneme manipulation difficulties than children with dyslexia because they are less likely to demonstrate decoding difficulties.

Rapid naming ability did not add predictive utility to the multinomial logistic regression model. However, children in the dyslexia group did demonstrate significantly greater difficulties on the Rapid Naming tests than children in the SCD group. This suggests that while rapid naming ability may not be a useful variable for differentiating between all three groups of poor readers, it can be used to discriminate between children in the dyslexia and SCD groups. Children in the dyslexia and mixed difficulty groups performed significantly more poorly than children in the SCD group on the Rapid Naming tests. These two groups of children also performed significantly more poorly on the decoding measures than children in the SCD group.

In contrast to the results obtained in this research, Catts et al. (2003) found that there was no significant difference between the dyslexia group and the SCD group on the rapid naming measure they administered to children in their study. There are two reasons why the results obtained in this research might differ to those reported by Catts and colleagues. First, this discrepancy may be due to the different way these authors operationalised rapid naming ability. In their study, Catts and colleagues administered a rapid picture naming test. This study used Rapid Digit Naming and Rapid Letter Naming tests. It is possible that children with dyslexia have greater difficulty encoding and recalling symbols than pictures. Previous research has found that alphanumeric naming speed is more strongly related to reading than non-alphanumeric naming speed (Araújo et al., 2015; Georgiou et al., 2009). Second, the age of the child may mediate the relationship between group assignment and rapid naming ability. In this research, children in the dyslexia group performed significantly worse on the Rapid Naming tests than children in the SCD group. Some research suggests that rapid naming difficulties may become more prominent over time in children with dyslexia (Araújo & Faísca, 2019). This suggests that the profile that children in the SCD and dyslexia groups exhibit on Rapid Naming tests may vary over time. The differences between these groups may be more pronounced in older children and less pronounced in children who are younger than those who participated in this research.

Rapid naming tests are more strongly related to reading fluency tests than reading accuracy tests across a range of orthographies (Araújo et al., 2015). This finding is consistent with the results reported in this study. Children in the dyslexia group performed significantly more poorly than children in the SCD group on the rapid naming and reading fluency assessments. This may be because reading fluency and rapid naming rely on some of the same cognitive processes. Both skills require attention to stimuli, visual processes used to identify and discriminate between letters, integration of visual information with stored orthographic and phonological representations, access and retrieval of phonological codes, and articulatory output (Araújo et al., 2015).

In the current study, the SCD group performed poorly on phonological awareness measures but not rapid naming measures. This suggests that the rapid naming difficulties exhibited by the dyslexia and mixed difficulty group are not due solely to phonological awareness difficulties. In addition, previous research has found that rapid naming ability is a good predictor of reading ability even after controlling for phonological awareness (Araújo & Faísca, 2019). This relationship has been found across writing systems (Araújo & Faísca, 2019) and orthographies of varying complexity (Frith et al., 1998; Handler & Fierson, 2011). These findings indicate that rapid naming ability relies, in part, on cognitive processes other than phonological awareness. These must be lower-level cognitive processes or skills that contribute to both alphanumeric naming speed and reading fluency but not phonological awareness.

Children with dyslexia demonstrate a distinct cognitive profile that is characterised by limited decoding ability in the absence of language comprehension difficulties. This profile can be used to differentiate between children with dyslexia and typically achieving children as well as children with other reading difficulties. These children also demonstrate phonological awareness and rapid naming difficulties. Although children assigned to the dyslexia group in this research exhibited difficulties across all the phonological awareness measures, the difficulties they demonstrated manipulating phonemes within words were particularly pronounced. It is likely these difficulties contribute to the decoding difficulties this group exhibited. However, it is less clear how the rapid naming difficulties that this group exhibited contribute to their decoding difficulties. While we may not know the exact aetiology of these difficulties, they do provide a reliable indicator of decoding difficulties.

6.4.2 SCD Group

The SCD group performed at a similar level to that of their typically achieving peers on all the tests that measured decoding ability (Word Attack, Letter-Word Identification, Word Reading Fluency, and Burt tests), the phoneme deletion test (Elision test) and both rapid naming tests. In contrast, these children demonstrated difficulties on all the tests that assessed language comprehension ability (Oral Comprehension, Oral Vocabulary, and BPVS-III tests) and three other tests that measured phonological awareness ability (Phonological Processing, Blending Words and Phoneme Isolation tests). Therefore, broad language difficulties are the defining characteristic of children in this group.

Children are hardwired to learn language. They do not need explicit instruction to become proficient with their own language in all but the most language-deprived backgrounds (Bishop & Snowling, 2004). Although most home environments are sufficient for language development, not all children are exposed to the formal decontextualised language that appears in print (Beck et al., 2013). It is possible that the difficulties exhibited by children in the SCD and mixed difficulty groups are due, in part, to limited experience with the language used in written texts (Beck et al., 2013).

It is also possible that a variable not assessed in this research could be the root cause of the difficulties exhibited by this group. For example, in addition to the difficulties identified in this study, children with language comprehension difficulties have been found to demonstrate impairment on tests that assess syntax knowledge, auditory perception, and verbal working memory (Leonard, 2014). It is unlikely that one of these variables alone is the root cause of the language difficulties exhibited by the SCD group because many of the difficulties noted above have also been observed in children with dyslexia (Bishop & Snowling, 2004; Diamanti et al., 2018; Lauterbach et al., 2017). Therefore, it is likely that a combination of these factors contribute to the language comprehension difficulties exhibited by this group. It is also likely that the relative importance of these factors varies from person to person. For example, the primary cause of one child’s language comprehension difficulties may be due to an impoverished home language environment while another child’s difficulties may be due, primarily, to impaired syntactic knowledge, or difficulties with one or more of the other cognitive processes associated with comprehension. Previous research has also found that the comprehension difficulties exhibited by poor comprehenders are not due to one fundamental weakness (Cain & Oakhill, 2007). This suggests that educators should first seek to identify what factors contribute to a child's language comprehension difficulties. Once these factors have been identified, an instructional programme should be devised to target these difficulties.

The results from this study show that children who exhibit the SCD profile perform at a similar level to that of children in the dyslexia group on reading comprehension measures. Their average score on the Passage Comprehension test placed them in the lowest 10th percentile of all readers. Although they performed at a similar level to children in the dyslexia group, they may be far more difficult for teachers to identify in the early primary years. Early reading instruction focuses on the development of decoding skills (Castles et al., 2018). It is likely that children who struggle with decoding will quickly come to the attention of teachers. These difficulties are characteristic of learners in either the dyslexia or the mixed difficulty groups. In contrast, children in the SCD group may not be identified by teachers because their decoding ability is similar to that of their typically developing peers. In addition, their language comprehension difficulties may not yet be apparent because the demands placed on them by instructional texts used with this age group do not yet exceed their language comprehension ability (Georgiou et al., 2009).

Older children with dyslexia may be able to use compensatory strategies to mitigate their decoding difficulties (Catts, Hogan, et al., 2005; Savage, 2006). Catts, Hogan, et al. (2005) followed a group of struggling readers from Grade 2 to Grade 8. They found that the proportion of poor readers who fell in the dyslexia subtype decreased over time from 32% in Grade 2 to 13% in Grade 8. During the same period, the proportion of children who fell in the

SCD group increased from 16% to 30%. The authors noted that this change was not due to poor readers changing in subgroup placement. Instead, they found that the children exhibited a similar profile over time. However, by eighth grade some of the children with dyslexia were able to apply compensatory strategies that meant they were no longer classified as poor readers. Many older children with dyslexia are able to decode words but have difficulty reading fluently, which is why timed reading assessments provide a better indication of decoding ability in older children (Tunmer & Chapman, 2012). Allowing extra time for reading tasks, using text-to-voice software, and using a reader for formal assessments are all strategies that can mitigate the difficulties exhibited by older children with dyslexia. Children with SCD do not have access to similar strategies or accommodations that can compensate for their difficulties. Instead, their limited ability to comprehend language may place a ceiling on their ability to comprehend text. Without support, this could lead to poor societal outcomes (Castles et al., 2018).

Research has found that children with language difficulties can make significant gains, and maintain them, in reading comprehension if they are provided with a programme that targets their oral language difficulties (Bowyer-Crane et al., 2008; Clarke et al., 2010). It is not just children with SCD that will benefit from this type of instruction. Both the mixed difficulty and SCD groups demonstrated language comprehension difficulties. These categories may include over 80% of all struggling readers. Because it is difficult to identify children with SCD, the most efficacious approach may be to ensure that all children are provided with reading instruction that also targets language comprehensions skills.

This research indicates that children with SCD demonstrate a cognitive profile that is different from that exhibited by children with dyslexia. Despite this identifiable profile, SCD is not defined within the most recent edition of the *Diagnostic and Statistical Manual of Mental Disorders: DSM-5*, published by the American Psychiatric Society (2013), nor is it described on the Ministry of Education's website. In contrast, the Ministry of Education's website provides a wealth of information on dyslexia (Ministry of Education, 2020) and the DSM-5 includes dyslexia under its list of neurodevelopmental disorders (American Psychiatric Association, 2013). Similar disorders have been excluded from the DSM-5 because they are typically defined through the use of exclusionary criteria, which describe what they are not, rather than what they are (Reilly et al., 2014). This research may contribute to addressing these concerns. The results indicate that the defining characteristics of this group are language comprehension difficulties in the absence of decoding difficulties. Like children with dyslexia, these children also demonstrate phonological awareness difficulties. However, they do not exhibit the same level of difficulty manipulating individual phonemes within words; nor do they demonstrate rapid naming difficulties.

In summary, the SCD group can be identified through their distinct cognitive profile. The proportion of poor readers who exhibit the SCD profile is similar to the proportion who exhibit the dyslexia profile. The two groups perform at a comparable level on reading comprehension tests. This indicates that a relatively large proportion of Aotearoa New Zealand's poor readers are not served adequately by policies that focus only on decoding difficulties.

6.4.3 Mixed Difficulty Group

Children in the mixed difficulty group demonstrated difficulties across all the tests that were administered in this research. They also performed significantly more poorly than children in the SCD and dyslexia groups on almost all of the assessments. The SVR predicts that children who perform poorly on both the decoding and the language comprehension variables will perform more poorly on measures of reading comprehension than children who perform poorly on only one of these variables. Notwithstanding this prediction, it was surprising how difficult this group found the reading comprehension test. Whereas the average score on the reading comprehension assessment for the dyslexia and SCD groups fell within the bottom 10th percentile, the average score for the mixed difficulty group fell within the bottom 1st percentile. This finding is consistent with other studies (Catts et al., 2003; Tunmer & Chapman, 2007) and indicates that the mixed difficulty group exhibit substantially greater reading comprehension difficulties than children in the other two poor reader groups.

Many of the risks associated with pronounced reading difficulties have been described earlier in this thesis. Some of the long-term impacts of severe reading difficulties include poor social and economic outcomes (OECD, 2011). The results from this research suggest that the children in the mixed difficulty group may require far greater support than children in the two other poor reader categories. This support should include reading programmes designed to address their reading difficulties. They may also require other accommodations to mitigate the reading comprehension difficulties they experience.

6.5 Identification Using Secondary Measures

The final research question investigated whether tests with teacher-level restrictions in Aotearoa New Zealand can be used to classify poor readers. A cluster analysis based on the Burt and BPVS-III tests identified the same poor reader groups as those predicted by the SVR, and these poor reader groups exhibited the expected poor reader profiles when compared across the 14 assessments. Subsequent analyses found that most children assigned to the dyslexia, SCD, or mixed difficulty group using the cluster analysis approach were assigned to the same poor reader group using the secondary cluster analysis, an approach based on the BPVS-III and Burt tests. These findings indicate that the BPVS-III and Burt tests provide a good approximation of the poor reader groupings that are identified using the WJIV assessments. However, there are limitations associated with this approach. A relatively large proportion of children assigned to the dyslexia group were not accurately classified using the secondary cluster analysis approach. These children were incorrectly assigned to either the SCD or the mixed difficulty groups. In addition, a relatively large proportion of children moved from the SCD group to the mixed difficulty group in the secondary cluster analysis approach. This indicates that a word identification measure provides an incomplete assessment of decoding ability and a receptive vocabulary test provides an incomplete assessment of language comprehension ability.

6.6 Implications

The results indicate that poor readers are not a homogeneous group of children. These children can be classified into one of three poor reader groups based on their decoding and language comprehension proficiency. These groups demonstrate distinct strengths and weaknesses. Therefore, it is likely that children will benefit from instructional programmes designed to address their specific learning needs. Once teachers have identified children in their class who exhibit reading difficulties, they must ascertain what poor reader profiles these children exhibit. These profiles should then form the basis for instructional programmes. This means that some children will benefit from programmes that focus on decoding, others will benefit from programmes that focus on language comprehension skills, and others will benefit from programmes that address both of these skills.

Teachers may be able to identify the various poor reader profiles in the early school years. For example, children in the dyslexia and mixed difficulty categories exhibited pronounced phoneme deletion difficulties. Phoneme awareness assessments do not require text so could be administered at the very start of primary school. The results from these tests could be used to identify children who are at heightened risk for decoding difficulties. Children who exhibit the SCD profile could also be identified prior to formal text instruction. These children will likely exhibit difficulties with tasks that tax their language comprehension ability in the early school years. Research suggests that these difficulties could be predicted by performance on televised and aural stories (Kendeou et al., 2006).

It may be especially important for teachers to identify children who exhibit the mixed difficulty profile in the early school years. These children demonstrated pronounced reading comprehension difficulties. The results indicate that this group are unlikely to comprehend the type of written text that other typically achieving children can read with little difficulty. In addition to providing targeted instruction, it is likely these children will require additional support across a range of classroom activities that include a reading component.

Teachers of Years 4, 5, and 6 children may be able to use the average raw scores reported in Table 5.10 to identify whether a child's reading difficulties are characteristic of a child with dyslexia, SCD, or a mixed difficulty profile. This assessment and classification approach may appeal to teachers because the Burt and BPVS-III tests do not take long to administer. Both tests can be administered within 15 minutes. Because Table 5.10 reports raw scores for each year level, teachers do not need to conduct any type of score conversion. The simplicity of this approach may be attractive to teachers. The Burt test can be accessed by teachers without additional training. However, not all teachers will be able to access the BPVS-III. These assessments can only be purchased and used by professionals with an NZCER Level B registration. To obtain a Level B registration, users must have a basic understanding of psychometric theory and specialist training in the area of test application (NZCER, n.d.-a). These requirements are more easily met than those associated with registration Level C, which is the registration level required for access to the WJIV. This training could be added to teacher education programmes. From 1 January 2022, teacher education programmes must include a focus on children with dyslexia. A focus on psychometric theory could be built into this part of teacher education programmes.

This research indicates that teachers cannot rely solely on the Burt and BPVS-III to assess children's decoding and language comprehension. The results suggest that some children find the Word Attack test particularly difficult. This may be because schools in Aotearoa New Zealand have not traditionally focused on systematic, explicit, and structured decoding instruction in the early school years (Tunmer et al., 2013b). As a result, some children may not have developed proficient word attack skills. Because word attack ability is a prerequisite for skilled decoding (Castles et al., 2018; Ehri, 2014), teachers must assess children's proficiency on this skill as well as their word identification ability.

In addition, analyses indicate that the BPVS-III, which assesses receptive vocabulary, provides an incomplete assessment of language comprehension ability. Teachers should also assess expressive vocabulary ability and other language comprehension skills. The results suggest that some children in this research found the expressive vocabulary test extremely difficult and far more difficult than the receptive vocabulary assessment. This finding is consistent with results reported by Chiappe et al. (2004). They found that struggling readers exhibited greater difficulties on a test that assessed expressive vocabulary ability than a test that assessed receptive vocabulary ability. Chiappe and colleagues' research focused on children in first, second, and third grade, and the researchers operationalised receptive and expressive vocabulary using assessments similar to those used in this research. A picture vocabulary test was used to assess children's receptive vocabulary, and expressive vocabulary was operationalised using a test that assessed children's ability to provide synonyms for target words. The authors hypothesised that children may have demonstrated greater difficulties with the expressive vocabulary test than the receptive vocabulary test because the expressive vocabulary test demands an oral response, which requires children to have developed a more complete phonological representation of the word than a receptive vocabulary test, which only requires children to point at the picture that matches a target word. This hypothesis is consistent with results obtained in this research because the children who demonstrated the greatest expressive vocabulary difficulties also demonstrated the greatest phonological awareness difficulties.

Once a teacher has identified the proximal cause of a child's reading difficulties, further assessments could be administered to identify what lower-level cognitive skills may be contributing to these difficulties. Some simple tests that assess these skills are included in *The New Zealand Dyslexia Handbook* (Nicholson & Dymock, 2015). The Ministry of Education has provided every school in New Zealand with a copy of this book. Teachers need only assess the lower-level cognitive skills that underpin the primary cause of a child's reading difficulties. This allows for more targeted assessment. Teachers could be guided by the cognitive foundations framework (Tunmer & Hoover, 2019; Wren, 2001) when determining what additional skills should be assessed because this framework is an extension of the SVR.

The previous paragraphs have focused on what implications this research might have on reading assessment in Aotearoa. However, the results from this research also have implications for reading instruction. Analyses indicated that 81% of the children in this study exhibited decoding difficulties, 88% of children exhibited language comprehension difficulties, and 83% of children exhibited difficulties with phoneme deletion tasks. This suggests that Tier 1 reading instruction provided within classrooms in Aotearoa New Zealand is not sufficient to address the difficulties that many children have with these skills. Explicit instruction of these skills has been found to reduce the proportion of children who go on to develop reading difficulties (Carson et al., 2013; Gillon et al., 2019, 2020; National Institute of Child Health and Human Development, 2000). This may indicate that children in Aotearoa New Zealand are not receiving sufficient and/or adequate instruction in these skills. It may also indicate that there are a relatively large proportion of children who will require more targeted instruction in these skills than that currently provided in Tier 1 reading programmes.

It is likely that Aotearoa New Zealand's instructional approach exacerbates the difficulties exhibited by children in the dyslexia group. Historically, reading programmes in Aotearoa New Zealand have been heavily influenced by whole language teaching. Although some children will learn to read irrespective of the instruction they receive, PIRLS data indicates that Aotearoa New Zealand's instructional approach has been insufficient for around 25% of Year 5 children (Ministry of Education, 2017). Instructional limitations may lead to a greater proportion of children in Aotearoa New Zealand developing reading difficulties than those in other countries that embrace a more evidence-based approach (Tunmer et al., 2013a). It may also mean that a greater proportion of poor readers fall within the dyslexia and mixed difficulty category within Aotearoa New Zealand than those in other nations that have adopted approaches that better support the development of decoding skills.

Previous research has suggested that many children in Aotearoa New Zealand do not receive adequate decoding instruction (Arrow, 2018; Chapman et al., 2018; Tunmer & Chapman, 2007; Tunmer et al., 2002). Inadequate instruction is one of the exclusionary criteria in many definitions of dyslexia (American Psychiatric Association, 2013; International Dyslexia Association, 2002; Tunmer & Greaney, 2010). The proportion of children identified as struggling readers can be substantially reduced through targeted instruction (Vellutino et al., 1996). However, if struggling readers are not provided with adequate instruction, it is not possible to determine whether their reading difficulties are primarily due to cognitive difficulties or instructional deficits. Vellutino et al. (1996) were able to substantially reduce the proportion of children identified as struggling readers with only one semester's worth of remediation. These findings suggest it may be possible to reduce the proportion of children assigned to the dyslexia and mixed difficulty categories by placing a greater focus on evidence-based decoding approaches within schools. The introduction section of this thesis identified some new initiatives designed to enhance decoding instruction within schools. These initiatives included additional teacher development, provision of decodable texts, and changes to Aotearoa New Zealand's Reading Recovery Programme. In time, these changes may lead to reduced rates of dyslexia and mixed reading difficulties because decoding difficulties are characteristic of children who are assigned to these groups.

The results suggest that teachers may require different resources to address the learning difficulties exhibited by the poor reader groups. For example, children who exhibit decoding difficulties may benefit from decodable texts. The Ministry of Education has recently advocated for their use to support children with dyslexia on the TKI website (Ministry of Education, 2020) and have indicated they will supply all schools with decodable texts from March 2021 (Ministry of Education, 2021a). In contrast, children with language comprehension difficulties may benefit more from strategy instruction that focuses on how to make connections within the text and other higher-level cognitive skills (Yeari & Lev, 2020). The National Reading Panel Report found that teaching higher-level cognitive skills resulted in improved reading comprehension (National Institute of Child Health and Human Development, 2000). They identified 16 different strategies that had been shown to improve aspects of children's reading comprehension. Considerable support was found for five strategies. These strategies included comprehension monitoring, graphic organisers, structural analysis, questioning, and summarising.

Analyses indicated that the three poor reader groups exhibit vocabulary difficulties. The difficulties exhibited by the SCD and mixed difficulty groups were particularly pronounced. This finding indicates that these children may benefit from instructional programmes that focus on vocabulary development. Research has shown that programmes that include vocabulary instruction can lead to improved reading comprehension outcomes (Beck et al., 2008; Kamhi & Catts, 2012; National Institute of Child Health and Human Development, 2000). Clarke et al. (2010) worked with children similar in age to those in this study. Like the children in this research, the participants in their study exhibited reading comprehension difficulties. Clarke and colleagues found that an oral language training programme that included vocabulary instruction led to improved reading comprehension outcomes. This suggests that teachers working with children similar to those in the current study should include vocabulary instruction within their reading programmes.

The results from this research may have implications for the Ministry of Education. Analyses indicate that struggling readers are just as likely to exhibit the SCD profile as they are to exhibit the dyslexia profile. However, the Ministry of Education does not dedicate a portion of their website to supporting learners with specific comprehension difficulties; nor has it signalled that it will develop a screening tool for this group of learners. Teachers may benefit from greater assistance in identifying and supporting children who exhibit this poor reader profile.

The Ministry of Education provides information on their website about learners who have speech language and communication needs (Ministry of Education, 2019b). Children with an SLI exhibit difficulties across a range of language skills (Bishop & Snowling, 2004; Cain & Oakhill, 2006; Lauterbach et al., 2017) but demonstrate relatively unaffected word reading ability (Cain & Oakhill, 2006). Children with an SLI who also demonstrate reading comprehension difficulties resemble children with an SCD (Kelso et al., 2007). Because of this similarity, Ministry of Education programmes that aim to enhance teachers' ability to identify and support struggling readers should make this connection.

6.7 Limitations

Care was taken to avoid or mitigate limitations associated with this research. Nevertheless, not all limitations can be controlled for and some limitations only become apparent after research has been completed. The following paragraphs acknowledge two limitations associated with this research: measurement error and comorbidity. These paragraphs also consider how these limitations could be mitigated.

This study was interested in children's performance on a range of constructs. Constructs are difficult to measure. They are labels that we give to a group of related behaviours (Shum et al., 2013), although they are not directly observable. To overcome this difficulty, a number of tests were used to assess each construct. The use of multiple assessments also allowed the full breadth of a construct to be explored. For example, some previous research has indicated that children in the dyslexia group do not perform significantly worse than children in the SCD group on phonological awareness tasks (Catts et al., 2003). However, by assessing a wide range of phonological awareness skills, this study was able to identify the one phonological skill (phoneme deletion) that could be used to differentiate between these groups of poor readers. Notwithstanding this approach, a construct can never be measured perfectly. While care was taken to mitigate the effect measurement error may have had on the results obtained in this research, measurement error can never be totally eliminated.

Human performance varies over time and context for a number of reasons that may not be observable to the assessor. For example, children's level of motivation, attention, and lethargy may vary from day to day, and this may affect their performance. This research attempted to mitigate these challenges by working with children for a short period and by assessing children across four different periods. While this approach likely minimised within-person variation on test performance, intrapersonal variation can never be fully eliminated.

This limitation was further mitigated by focusing on group-level data, rather than individual performances. The WJIV technical manual (McGrew et al., 2014) reports high levels of reliability across the tests that were administered. This indicates that an individual's score on a test is unlikely to change if the child is assessed again under similar conditions. Future research could confirm that scores are stable over time by administering parallel assessments at two different time points. This approach is obviously time consuming. While it may address the difficulties associated with test-retest reliability, it may create new difficulties such as test fatigue. Therefore, the most efficacious approach may still be the one adopted in this research, in which test reliability is acknowledged as a potential limitation. Given the high levels of reliability reported in the manual, this approach may still be preferable to other approaches that create different limitations.

There is comorbidity between reading difficulties, ADHD (Shaywitz et al., 2008), maths difficulties (Moll et al., 2016), and other language disorders (Duff et al., 2008). This study made no attempt to exclude children with additional disorders. Comorbidity makes it difficult to ascertain whether the cognitive profiles one observes are due to factors unique to specific types of reading difficulties or due, at least in part, to some comorbid condition. Future research could attempt to exclude children with reading difficulties who have additional comorbidities or it could include tests that identify these conditions and control for them statistically in analyses.

6.8 Future Research Opportunities

This research suggests that poor readers can be assigned to one of three poor reader groups. This means that the reading difficulties exhibited by these children are likely due to decoding difficulties, language comprehension difficulties, or difficulties with both of these skills. These skills can be improved through targeted instruction (Aaron et al., 2008; Arrow, 2018; Clarke et al., 2010). Therefore, this classification approach should be of interest to educators. If educators can accurately identify the root cause of a child's reading difficulties, they should be able to provide targeted instruction to support this child. Aaron and colleagues (2008) found tentative support for this hypothesis. Their research found that children responded more positively to a programme that addressed their specific needs than an undifferentiated instructional approach. In their research, children were categorised as having either decoding or language comprehension difficulties; no mixed difficulty group was included in this research. Future research could investigate whether grouping children, using the methodology described in this research, and then providing targeted instruction to address specific areas of weakness leads to greater gains in reading comprehension performance than a one-size-fits-all instructional approach, such as that currently offered in Aotearoa New Zealand via Reading Recovery.

This research focused on children who were in Years 4, 5, and 6 for reasons described in the participants section of this thesis. Initially, future research could attempt to replicate these findings with a different group of participants the same age as those in this study. It should also examine whether similar patterns are found at different year levels. For example, research indicates that language comprehension ability becomes a better predictor of reading comprehension proficiency than decoding ability in the latter school years (Adlof et al., 2006; Ebert & Scott, 2016; Hoover & Gough, 1990; Kershaw & Schatschneider, 2012; Tilstra et al., 2009). Catts, Hogan, et al. (2005) suggested that this pattern explains why the proportion of poor readers assigned to the SCD category in their study increased over time relative to the proportion of children assigned to the dyslexia category. Research, using the classification approaches described here, should investigate whether this pattern is observed with older readers in Aotearoa New Zealand. Researchers may like to focus on the first year of secondary school because these children are the same age as the Grade 8 participants in the study conducted by Catts and colleagues (2005). Alternatively, they could focus on children in Year 11 (15–16 years old) because this is the first year most applications for SAC are made for NZQA exams. This research may find that a different set of variables should be used to predict group membership. For example, some research has found that fluency measures provide a better indication of decoding ability in older children than accuracy-only measures (Kershaw & Schatschneider, 2012).

Classification using the Burt and BPVS-III tests provided a good approximation of the cluster analysis approach that used the decoding and language comprehension variables (see Section 5.2.2). However, there were limitations associated with this approach. A relatively large proportion of children in the dyslexia category were incorrectly assigned to the SCD or mixed difficulty group, and a relatively large proportion of children in the SCD group were incorrectly assigned to the mixed difficulty group. It is likely that the discrepancies observed between these approaches are due to the more narrow assessment of decoding and language ability that are provided by the Burt and BPVS-III tests. Future research should examine whether assessing decoding ability using the Burt test and a word attack test and assessing language comprehension using the BPVS-III and a listening comprehension test improves the accuracy of this classification approach. When identifying potential word attack and listening comprehension tests, researchers should ensure that these tests can be accessed and administered by classroom teachers because that was the focus of this classification approach.

Future research could include a range of tests that assess executive functioning skills. Executive function includes a range of skills that an individual uses to achieve a goal (Georgiou & Das, 2018). Some research suggests that executive functioning skills, including working memory (Cain & Oakhill, 2006; Kendeou et al., 2014; Potocki et al., 2017; Vellutino et al., 1996), inhibition (Barnes et al., 2004; De Beni & Palladino, 2000; Potocki et al., 2017), and attention allocation may play a role in reading comprehension (Kendeou et al., 2014;

Long et al., 1997). Research could investigate whether the poor reader groups demonstrate a different performance profile across these assessments. It is possible that some groups may demonstrate greater difficulties on these variables than other groups, and these difficulties may contribute to their decoding and/or language comprehension difficulties.

Chapter 7 Conclusion

The previous section discussed many important findings from this research. It sought to explain the results that were obtained and considered the implications associated with these findings. This section reviews the three key findings from this research.

Previous SVR classification studies have used cut-off points to assign children to poor reader groups based on the aetiology of their reading difficulty. These previous studies have identified a group of children who exhibit reading difficulties in the absence of decoding and/or language comprehension difficulties. The existence of this group is not predicted by the model. Analyses associated with the first research question in this study investigated whether alternative classification approaches, based on the SVR, provided a better explanation for children's reading difficulties. Classification approaches based on significant differences and cluster analyses were performed, and these classification approaches were compared with the traditional classification approach. Classification based on a cluster analysis provided the best explanation for children's reading difficulties. This approach identified the three poor reader groups predicted by the model. It indicated that children who were assigned to the unexplained poor reader group in the traditional classification approach could be more accurately assigned to one of the other poor reader categories using the cluster analysis approach. Therefore, the results from this research suggest that the SVR can be used for classification purposes.

Analyses associated with the second research question investigated whether the poor reader groups, which were identified using the cluster analysis approach, demonstrated distinct cognitive profiles. These analyses indicated that the poor reader groups exhibit contrasting strengths and weaknesses. Compared with the SCD group, the dyslexia group demonstrated significantly greater difficulty on tests that assessed decoding ability, phoneme deletion ability, and rapid naming ability. In contrast, they performed significantly better than the SCD group on tests that assessed oral comprehension and oral vocabulary ability. The mixed difficulty group performed significantly worse than the dyslexia and SCD groups on almost every test that was administered. The magnitude of their reading comprehension difficulties was also far greater than that of the other two groups. Both the dyslexia group and the SCD group performed around the 10th percentile on the test that assessed reading comprehension ability. In contrast, the mixed difficulty group performed within the 1st percentile on this test.

The final research question investigated whether tests with teacher-level restrictions could be used to classify poor readers. Classification based on a cluster analysis that used children's Burt and BPVS-III scores identified the three poor reader groups predicted by the SVR. These groups were then compared across a range of cognitive processes. Analyses indicated that these groups demonstrated a cognitive profile similar to the profile identified in the analyses associated with the second research question. Notwithstanding these findings, limitations with this classification approach were also identified. A multinomial logistic regression analysis indicated that assignment to the dyslexia group was not predicted accurately using this approach.

This study adds to the rich history of research on reading difficulties. It addresses many of the limitations associated with previous classification approaches and provides further evidence that these groups of poor readers demonstrate distinct cognitive profiles. While this research addressed specific gaps in the literature, it has also identified future research pathways that could further our understanding in this area. Therefore, this research is certainly not the final note on the identification and classification of reading difficulties.

Instead, it is hoped this study may form the basis for further research, which will continue to enhance our understanding of children's reading difficulties.

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Appendix A

Table A1

Factor Loadings

	Decoding	Language Comprehension
Word Attack	.855	
Letter-Word ID	.927	
Word Reading Fluency	.790	
Burt	.888	
Oral Comprehension		.830
Oral Vocab		.823
BPVS-III		.840

Table A2

Comparisons by Poor Reader Group Based on Classification Using Factor Scores

Test	Group	*N*	*M*	*SD*	Significant differences
Passage Comp	Mixed	50	68.12	9.61	Mixed < Dyslexia[a]
$F(2,203) = 59.922$, $p < .001$	Dyslexia	64	78.84	9.18	Mixed < SCD[a]
Welch: (2,102.340) = 55.419, $p < .001$	SCD	92	83.17	6.20	Dyslexia < SCD[a]
Brown–Forsythe: (2,143.724) = 53.173, $p < .001$					
Word Attack	Mixed	50	74.38	15.39	Mixed < Dyslexia[c]
$F(2,203) = 88.355$, $p < .001$	Dyslexia	64	79.27	7.64	Mixed < SCD[a]
Welch: (2,104.169) = 103.776, $p < .001$	SCD	92	95.77	8.01	Dyslexia < SCD[a]
Brown–Forsythe: (2,93.502) = 72.079, $p < .001$					
Letter-Word Identification	Mixed	50	73.94	10.99	Mixed < Dyslexia[a]
$F(2,203) = 99.324$, $p < .001$	Dyslexia	64	80.28	8.77	Mixed < SCD[a]
Welch: (2,104.041) = 98.031, $p < .001$	SCD	92	93.96	7.02	Dyslexia < SCD[a]
Brown–Forsythe: (2,131.866) = 86.849, $p < .001$					
Burt	Mixed	50	77.48	8.13	Mixed < SCD[c]
$F(2,203) = 93.667$, $p < .001$	Dyslexia	64	79.64	7.95	Dyslexia < SCD[c]
	SCD	92	93.90	7.89	
Word Reading Fluency	Mixed	50	76.56	9.13	Mixed < Dyslexia[c]
$F(2,203) = 57.876$, $p < .001$	Dyslexia	64	83.36	10.51	Mixed < SCD[c]
	SCD	92	94.26	9.63	Dyslexia < SCD[c]
Oral Comprehension	Mixed	50	72.68	10.95	Mixed < Dyslexia[c]
$F(2,203) = 89.396$, $p < .001$	Dyslexia	64	95.86	7.30	Mixed < SCD[c]
	SCD	92	86.54	9.34	Dyslexia > SCD[c]
Oral Vocabulary	Mixed	50	68.06	11.93	Mixed < Dyslexia[a]
$F(2,203) = 76.017$, $p < .001$	Dyslexia	64	89.58	9.64	Mixed < SCD[a]
Welch: (2,107.821) = 56.659, $p < .001$	SCD	92	85.64	8.50	Dyslexia > SCD[a]
Brown–Forsythe: (2,140.312) = 68.600, $p < .001$					
BPVS-III	Mixed	50	74.62	6.30	Mixed < Dyslexia[a]
$F(2,203) = 45.932$, $p < .001$	Dyslexia	64	90.72	11.66	Mixed < SCD[a]
Welch: (2,121.487) = 45.930, $p < .001$	SCD	92	81.15	8.31	Dyslexia > SCD[a]
Brown–Forsythe: (2,150.805) = 46.912, $p < .001$					

Table A2 continued

Comparisons by Poor Reader Group Based on Classification Using Factor Scores

Test	Group	*N*	*M*	*SD*	Significant differences
Phonological Processing	Mixed	50	72.48	11.95	Mixed < Dyslexia[c]
F(2,203) = 21.581, *p* < .001	Dyslexia	64	80.08	11.75	Mixed < SCD[c]
	SCD	92	85.67	11.55	Dyslexia < SCD[c]
Elision	Mixed	50	78.40	9.28	Mixed < SCD[a]
F(2,203) = 47.968, *p* < .001	Dyslexia	64	80.47	7.39	Dyslexia < SCD[a]
Welch: (2,119.975) = 45.131, *p* < .001	SCD	92	91.96	10.03	
Brown–Forsythe: (2,175.219) = 50.117, *p* < .001					
Blending Words	Mixed	50	75.70	12.37	Mixed < Dyslexia[c]
F(2,203) = 7.856, *p* < .001	Dyslexia	64	82.89	13.59	Mixed < SCD[c]
	SCD	92	84.51	12.67	
Phoneme Isolation	Mixed	50	79.20	10.12	Mixed < Dyslexia[a]
F(2,203) = 6.140, *p* < .001	Dyslexia	64	86.88	13.56	
Welch: (2,117.751) = 6.144, *p* < .001	SCD	92	83.37	10.87	
Brown–Forsythe: (2,171.291) = 6.137, *p* < .001					
Rapid Digit Naming	Mixed	50	88.40	9.34	Mixed < SCD[a]
F(2,203) = 25.981, *p* < .001	Dyslexia	64	88.05	6.88	Dyslexia < SCD[a]
Welch: (2,120.071) = 25.221, *p* < .001	SCD	92	97.72	10.88	
Brown–Forsythe: (2,176.099) = 28.108, *p* < .001					
Rapid Letter Naming	Mixed	50	87.90	8.27	Mixed < SCD[c]
F(2,203) = 20.351, *p* < .001	Dyslexia	64	87.81	7.71	Dyslexia < SCD[c]
	SCD	92	95.60	9.46	

Note. Significant differences between groups are recorded in the right-hand column. Greater than and less than signs denote the directions of these differences.

[a]Significant difference identified using both Tukey's honestly significant difference and Games–Howell Post hoc tests.

[b]Significant difference identified using Games–Howell post hoc test only.

[c] Significant difference identified using Tukey's honestly significant difference post hoc test only.

Appendix B

Figure B1

Classification by Significant Differences (90% Confidence Interval)

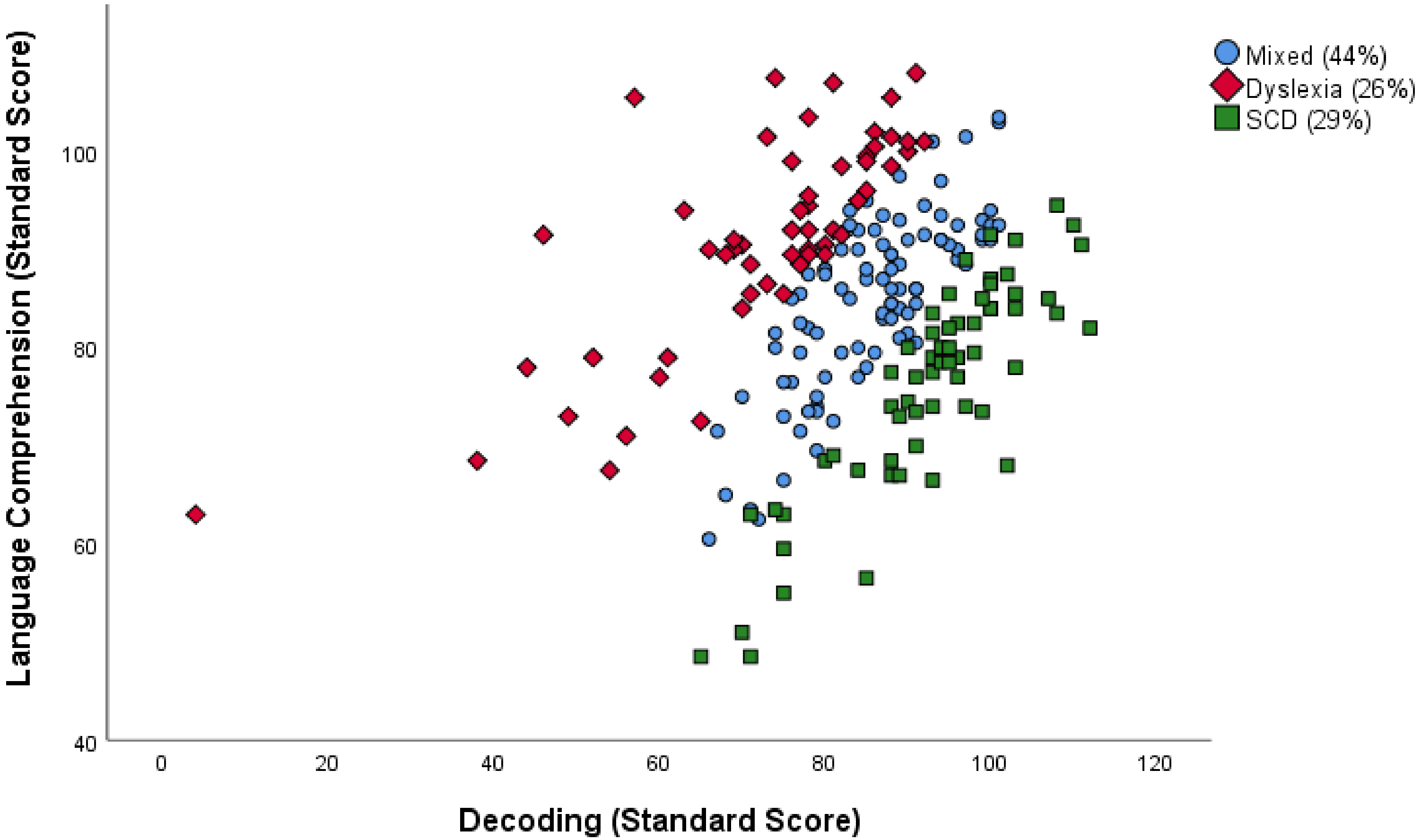

Table B1

Parameter Estimates Significant Difference Approach (90% Confidence Interval)

Group		*B*	*SE*	Wald	*df*	Sig.	Exp(*B*)	95% CI for Exp(*B*)	
								Lower limit	Upper limit
Mixed	Intercept	−4.306	2.271	3.596	1	.058			
Difficulty	Elision	.035	.026	1.841	1	.175	1.035	.985	1.088
	Burt	**.097**	**.023**	**17.768**	**1**	**.000**	**1.102**	**1.054**	**1.153**
	BPVS-III	**−.069**	**.019**	**12.842**	**1**	**.000**	**.933**	**.899**	**.969**
SCD	Intercept	−5.852	2.965	3.895	1	.048			
	Elision	**.138**	**.033**	**17.393**	**1**	**.000**	**1.148**	**1.076**	**1.225**
	Burt	**.115**	**.031**	**13.364**	**1**	**.000**	**1.121**	**1.055**	**1.193**
	BPVS-III	**−.189**	**.032**	**34.091**	**1**	**.000**	**.828**	**.777**	**.882**

Note. The reference category is Dyslexia.

Table B2

Proportion of Children Correctly Classified

	Mixed difficulty	Dyslexia	SCD	Total
% Predicted accurately	65.6%	56.4%	63.9%	62.7%

Appendix C

Figure C1

Classification by Significant Differences (95% Confidence Interval)

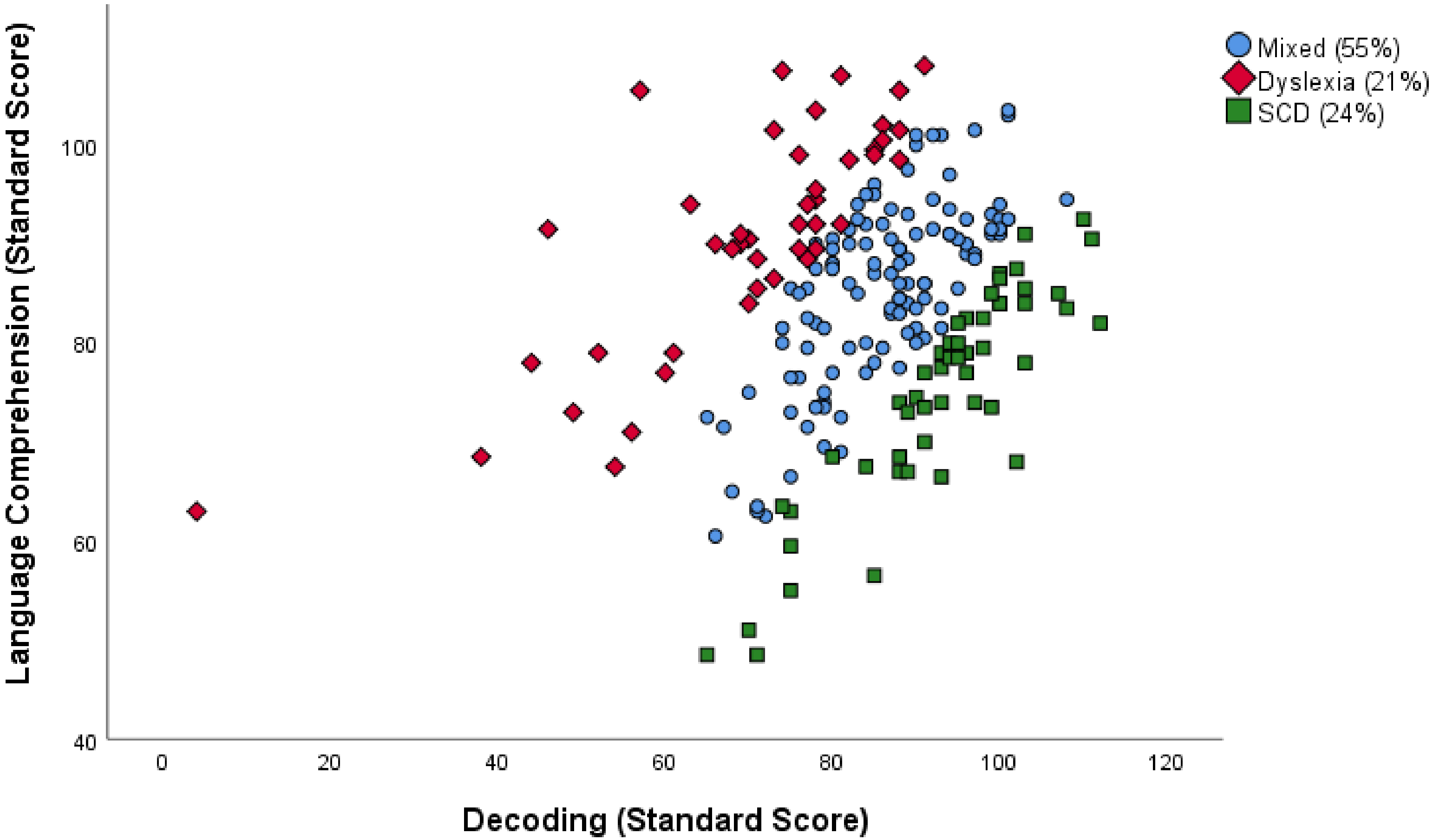

Table C1

Parameter Estimates Significant Difference Approach (90% Confidence Interval)

Group		B	*SE*	Wald	*df*	Sig.	Exp(*B*)	95% CI for Exp(*B*)	
								Lower limit	Upper limit
Mixed Difficulty	Intercept	−5.136	2.389	4.624	1	.032			
	Elision	**.083**	**.031**	**7.225**	**1**	**.007**	**1.087**	**1.023**	**1.155**
	Burt	**.089**	**.024**	**13.975**	**1**	**.000**	**1.094**	**1.043**	**1.146**
	BPVS-III	**−.058**	**.019**	**9.256**	**1**	**.002**	**.944**	**.909**	**.980**
	Phonological Processing	−.036	.019	3.669	1	.055	.964	.929	1.001
SCD	Intercept	−6.428	3.110	4.272	1	.039			
	Elision	**.171**	**.039**	**19.357**	**1**	**.000**	**1.186**	**1.099**	**1.280**
	Burt	**.119**	**.033**	**13.357**	**1**	**.000**	**1.127**	**1.057**	**1.201**
	BPVS-III	**−.149**	**.031**	**23.743**	**1**	**.000**	**.862**	**.811**	**.915**
	Phonological Processing	**−.069**	**.025**	**7.248**	**1**	**.007**	**.934**	**.888**	**.982**

Note. The reference category is Dyslexia.

Table C2

Proportion of Children Correctly Classified

	Mixed difficulty	Dyslexia	SCD	Total
% Predicted accurately	86.0%	54.5%	41.2%	68.4%